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A STUDY OF FUEL SUPPLIES FOR
EMERGENCY POWER GENERATION AT
AIR LOGISTICS CENTERS,

10 ~~Captain~~ Stephen J. Mott, USAF
Captain Sherman D. Nelson, USAF

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The uncertainty of the availability of future supplies of petroleum has raised the possibility that a future electrical power curtailment could be accompanied by a simultaneous curtailment of petroleum fuel supplies. During such curtailments the ability of the Air Force Logistics Command's Air Logistics Centers to accomplish the essential operations required by a wartime scenario may depend upon the use of emergency back-up generators to provide electrical power to critical facilities. After obtaining information about the back-up generators at each Air Logistics Center and the quantities of fuel likely to be available for generator use during a supply curtailment, a linear programming computer package is used to determine the maximum length of time each Air Logistics Center can continue to meet its minimum critical operating requirements during a complete curtailment of commercially supplied electrical power and petroleum fuels. After reviewing the results of the computer analyses, the authors conclude that a long-term curtailment may have significant adverse impact on the ability of the Air Logistics Centers to meet critical operating requirements during a wartime scenario.

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A STUDY OF FUEL SUPPLIES FOR EMERGENCY POWER GENERATION AT AIR LOGISTICS CENTERS

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Facilities Management

By

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and

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COMMITTEE CHAIRMAN

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CHAPTER I

INTRODUCTION

Background

The era of inexpensive and abundant petroleum resources for the United States ended in 1973 when the Organization of Petroleum Exporting Countries decided to drastically curtail exports of crude oil to the United States and other western industrialized nations, and to simultaneously increase to an unprecedented high the price of all exported petroleum. The oil embargo, rather than being a temporary inconvenience, emphasized to Americans the vulnerability of the United States' economy to interruptions in the supplies of foreign crude oil to domestic refineries. Though the impact of the embargo was reflected almost immediately through an increase in gasoline prices and nationwide gasoline allocation problems, the implications for continuing long-term effects on American industry were probably even more disconcerting.

The energy crisis of 1974 surprised most Americans, but a 1974 paper noted that an "energy shortfall was predictable [to what now is evident as good accuracy] from simple arithmetic projections a considerable time ago [26:4]." The turning point apparently occurred in 1969 when the demand for oil and gas energy in the United States finally outstripped the supply from domestic sources (6:3). Since that time, not only has the United States failed to reduce energy demands to a level capable of being satisfied by domestic suppliers, but has continued to increase the range by which consumption exceeds domestic production. By 1976 annual consumption was exceeding domestic production by 1.6 billion barrels of oil and 12.8 billion cubic feet of natural gas (17:3).

Since approximately 70 percent of United States petroleum imports originate in nations belonging to the Organization of Petroleum Exporting Countries, the potential for another oil embargo is always present. The international political situation may again inspire the use of an oil embargo as a method for influencing foreign policies of the United States. The strategic flexibility of the United States then, has been significantly reduced because of the increased dependence on oil imports (17:8).

The electrical power produced by utilities accounts for approximately 25 percent of total energy requirements in the United States, but will account for 37 percent of the total requirement by 1985 (17:17). Unfortunately, much of this electrical power is produced by utilities with generating plants that burn oil or natural gas, both of which will continue to become more scarce and which will continue to be supplied in part by imports from foreign countries (17:3). Since oil and natural gas have been available until recently at unrealistically maintained low prices, the use of alternate abundant fuels such as coal and reactor quality fissionable materials has not been vigorously pursued. Concerns about the potential harm to the environment caused by the use of coal and nuclear power plants have also inhibited the development of power plants using these abundant domestic fuels. Consequently, electric utility companies are potentially very vulnerable to another curtailment of petroleum imports. Of course, the breakdown of the reactor cooling system at the Three Mile Island nuclear electric generating plant in the Spring of 1979 made it clear that all power plants are vulnerable to unforeseeable circumstances which may cause losses of electrical power for considerable periods of time. In the case of the accident at Three Mile Island, the power plant will not be in operation again for several years, if it is indeed ever again reactivated.

Though efforts are being increased to make the United States more independent of foreign sources of energy supplies, mainly through conservation and development of alternate domestic resources, for the foreseeable future the United States will still be dependent on foreign energy supplies. A study by the Strategic Studies Institute completed in February 1978 concluded that:

> . . . even with increased emphasis on conservation and accelerated development of additional domestic resources, there is little likelihood that the United States can increase its energy self-sufficiency by 1987. The most optimistic of forecasts indicate that the nation is likely to do no better than hold its present position [17:22].

The Defense Advanced Research Projects Agency predicted in 1972 that an energy shortage would "have deleterious effects on national security, in particular in economic, political, and military terms [8:29]." As the increase in energy usage at military facilities paralleled the increased usage in the economy as a whole, the Agency was particularly concerned with the fact that "nearly all U.S. military installations met their energy need through procurement from off-site commercial supplies [8:12]." This being the case, military facilities were not only susceptible to curtailments in the supply of electrical power and petroleum-based fuels caused by oil and gas shortages generated by foreign suppliers, but were also susceptible to curtailments caused by labor strikes, utility plant generating equipment failures, natural disasters, and even price disputes. In addition, military installations are generally not guaranteed an allocation of electricity during an energy shortage, as are police departments, fire departments, hospitals, and other facilities considered critical by the civilian community (19:26).

The deleterious effects of massive curtailments of electrical power were dramatically demonstrated during the blackout of the northeastern United States in 1965. Regarding that blackout the Department of Defense (DOD) stated:

> One of the lessons learned by the DOD and the entire civilian sector from the massive power failure of November 9, 1965 is that there is no substitute for adequate auxiliary electrical power systems in an emergency. The thousands of these systems which are installed by the civilian community in the wake of that great power failure is adequate testimony for this point. Furthermore, during that power failure, which caused a blackout in the entire northeastern United States, the DOD, because of a sound policy of the use of auxiliary electric power, did not suffer any loss of mission essential operations [7:25].

Of the 1.46 quadrillion British thermal units of energy consumed by the Department of Defense in fiscal year 1977, the U.S. Air Force consumed 48 percent of the total (4:3-2). Facility operations accounted for 30 percent of the Air Force's total consumption (4:3-2). As the energy supply situation becomes increasingly more acute in the future, the likelihood of electrical power and petroleum-based fuel curtailments at Air Force installations may increase commensurately. This increases the possibility that facility operations may also be adversely affected more than the past when supplies of electrical power and petroleum fuels were generally plentiful and almost guaranteed.

The Air Force has recognized the need for bases to reduce their dependence of commercially supplied energy, and most efforts have been directed towards reducing total demand through conservation. Alternate energy resources for military installations are also being considered as future possible partial solutions to the Air Force's facility energy problem. Air Force regulations, however, currently require the use of existing commercial utility sources whenever economically feasible, rather than constructing or expanding Air Force power sources (24:4). According to the Construction Engineering Research Laboratory, an

> . . . installation cannot economically compete with a utility company, because the utility company can use its much larger demand base and diversity to obtain large economies of scale [6:10].

Consequently, the dependence of military installations on commercially supplied electrical power will probably continue for many years in the future.

The Air Force regulation establishing the policies for obtaining electrical power from public utilities also recognizes that service interruptions may jeopardize the ability of an Air Force base to perform its mission. This regulation, AFR 91-5, states:

> In a local emergency shortage, local utility companies may be forced to curtail or interrupt service to an Air Force base to the extent that it will endanger the mission [24:4].

This regulation also requires the installation commander to take "the necessary conservation action immediately, and make emergency provision for alternate temporary service to meet minimum requirements of the installation [24:4]." The development of a contingency plan for each base to reduce electrical power in an emergency and to use emergency generators to assume part of the electrical load is also required (22:4). The increased probability of energy supply curtailments in the future makes such a contingency plan even more important.

Problem Statement

A future long-term curtailment of electrical supplies which coincides with a shortage of petroleum fuels could adversely affect the ability of Air Force installations to satisfy their critical operating requirements once initial stocks of emergency fuels have been exhausted. To date, no study has been found which determines the length of time that Air Force installations can operate using emergency power before resupply of fuels becomes imperative.

Justification

A review of the current literature addressing the energy problems of military installations indicates the lack of studies specifically relating to the emergency generator fuel requirements of military installations during periods of energy supply curtailments. The pressing need for energy conservation and the development of alternate sources of energy for the future dominates the attentions of most groups engaged in energy research. Evidence indicates that back-up emergency power capabilities need to be examined however, as problems with some Air Force installations' abilities to provide reliable emergency power do exist.

For example, AFR 91-4 requires annual review of "the generator and system capacity and loads, storage of fuel and lube oil, and the feasibility of shedding nonessential loads [20:16]." This requirement notwithstanding, a 1977 General Accounting Office (GAO) study of the management of emergency power generators by the Department of Defense stated that, in regard to emergency power requirements at Robins Air Force Base, Georgia,

> Annual reviews required under Air Force regulations were not being made. Base Civil Engineering informed us that as long as complaints were not received, they considered that all needs were being satisfactorily met [7:30].

At Castle Air Force Base, California the GAO was told that

> . . . to determine whether a continuing requirement exists for generators, the Base Civil Engineer each year verbally asks all generator users whether their missions have changed [7:29].

The Department of Defense (DOD) indicated the need for more information regarding potential problems faced by defense installations during an energy shortage in a study in 1978 which stated:

> In accomplishing its mission in an energy shortage situation, DOD requires accurate information to assess the energy consequences of its present operations (and conversely), as well as to develop new programs to deal with both energy and mission-related problems [8:B-1].

Delimitation

With over 85 active Air Force installations in the continental United States, a study which attempted to gather and analyze data from each base within the time constraints imposed would be difficult, if not impossible, to complete. In the attempt to answer the research questions soon to be posed, it is anticipated that a critical and in-depth analysis of the base emergency power requirements and fuel supplies will have to be made. For this reason, the scope of this study will be limited to a small sample of Air Force installations. Since policy at any particular base is generally a reflection of both Air Force and parent command policies, it appears to be sound practice to study bases under a single major air command. The colocation of the Air Force Institute of Technology with a major air command headquarters, that of Air Force Logistics Command (AFLC), permits ready access to data concerning not only the headquarters base, Wright-Patterson Air Force Base, but also other major installations in the command. In regard to the industrial functions performed by AFLC, the Air Logistics Centers (ALCs) represent a census of major AFLC installations, and this study will be limited to the ALCs for this reason. In addition to the contribution of readily accessible data through their headquarters base, the ALCs prove to be excellent elements of study for several other reasons.

First, the diverse locations of the ALCs throughout the United States permit the study of energy systems designed for differing climates, and hence will direct a look at a greater variety of power requirements than would studying bases located in one particular climatic or geographic area. Second, most major AFLC installations can be classified as industrial power users. The nature of the work accomplished at these installations makes them heavily dependent on electrical power supplies, and consequently an effective contingency plan for restoring electrical power during an emergency is especially important. Third, the fact that the bases are located in different geographic areas of the nation precludes the possibility that several bases are part of the same electrical power grid system, and makes it very unlikely that any of the bases are supplied with power by the same major commercial utility company. Finally, the important role of AFLC bases in maintaining the defensive capability of the United States makes them excellent candidates for study. The inability of major AFLC bases to meet their minimum critical operating requirements during a curtailment of electrical power would most likely have adverse effects on all other major air commands, particularly during wartime.

Research Objective

The objective of this thesis is to determine the maximum length of time that the Air Logistics Centers can continue to meet their critical operating requirements by using emergency back-up generators during a long-term curtailment of commercially supplied electrical power and petroleum fuels.

Research Questions

1. At each Air Logistics Center, what emergency power sources have been identified as necessary to meet critical operating requirements?

2. What is the fuel consumption rate for each emergency power source at each Air Logistics Center?

3. By type, what quantities of fuel are available at each Air Logistics Center to meet the requirements of back-up emergency power sources?

4. Relating fuel supplies and consumption rates to time, what is the maximum length of time each Air Logistics Center can operate on emergency power during a curtailment of commercially supplied electrical power and petroleum fuels?

CHAPTER II

METHODOLOGY

Introduction

The procedures for satisfactorily obtaining answers to the four research questions outlined in Chapter I can be divided in two general areas--data collection and data analysis. Providing answers to the first three research questions is the principal objective of the data collection effort, and analysis of the data will yield the answer to the fourth research question regarding the maximum length of time each ALC can operate using emergency back-up power during a curtailment of commercially supplied electrical power and petroleum fuels. In this chapter terms to be used in the discussion of the data collection and analysis procedures are defined, the population of interest is specifically identified, the data collection procedure is outlined, the data analysis procedure is discussed, and assumptions made during development of data collection and analysis procedures are summarized.

Definition of Terms

The following terms are used frequently throughout this study, and a thorough understanding of their definitions is essential to the reader. Definitions marked with an asterisk are taken directly from Air Force Regulation 91-4, Maintenance and Operation of Electrical Power Systems (22:1).

1. *Base generated power--that electrical power generated in-house in support of Air Force facilities.

2. *Commercial power--that electrical power obtained from a commercial utility in support of Air Force facilities.

3. *Emergency power--an alternate source of electrical power available for use in the event of a failure of the primary power source.

4. Fuel consumption rate--the amount of fuel used per unit time (usually expressed in gallons/hour).

5. Load shedding--a reduction in electrical power total demand realized through selective shut-down of non-essential loads.

6. Minimum critical operating requirement--a requirement, as defined by the agency having responsibility for that requirement, which, if not met, will result in serious mission degradation or failure.

7. Mobile generator--a generator designed to be readily transported to location of use. (Includes all generators not identified as real property installed equipment.)

8. Output power rating--the electrical power, measured in kilowatts, that a generator is capable of supplying to a load.

Description of Population

As indicated in Chapter I, this study is limited to the Air Logistics Centers of AFLC. These installations are:

1. McClellan Air Force Base, California
2. Hill Air Force Base, Utah
3. Tinker Air Force Base, Oklahoma
4. Kelly Air Force Base, Texas
5. Robins Air Force Base, Georgia

Results from this study cannot be extended in general to other Air Force installations. The ALCs being studied are not a random sample of any larger population. Consequently, inferences about the larger population of installations which may include all Air Force bases or possibly all Department of Defense installations cannot be made from this study. However, the numerical techniques and method of analysis employed are not limited only to the population under study here and therefore could be used in the study of other installations.

Measurement Parameters and Variables

For each ALC, several parameters will have to be measured or obtained to facilitate the derivation and grouping of variables used in the data analysis. These parameters fall into two categories; those which are characteristics of the emergency power systems and those which are characteristics of the emergency fuel stocks. Necessary characteristics of the emergency power systems at each ALC and a description of how they are utilized are as follows:

1. Type of system (diesel, gas turbine, spark fired internal combustion, etc.)--necessary to determine the type of fuel required for any particular generator.

2. Power output rating--necessary to determine the fuel consumption of the particular generator in question. Used in conjunction with fuel type and manufacturer/model number to determine fuel consumption rate.

3. Fuel type (gasoline, diesel fuel #2, etc.)--necessary to properly identify each type of fuel which can impact an ALC's ability to provide emergency power. Used in conjunction with manufacturer/model number and power output rating to obtain fuel consumption rate.

4. Fuel consumption rate (R)--determined for each generator and used as an independent variable in the analysis section of this study.

5. Fuel tank capacity (F)--measured in gallons for each generator and used as an independent variable in the analysis section of this study.

6. Associated facility--information to be maintained, for each generator, so that results of this study can later be specified as to particular impact on the ALC in question.

7. Manufacturer/model number--used in conjunction with fuel type and power output rating to determine fuel consumption.

Necessary characteristics of emergency fuel stocks at each ALC and a description of how utilized are as follows:

1. Fuel type (gasoline, diesel fuel #2, etc.)--necessary to identify type of generator to be supplied from a particular fuel stock.

2. Fuel quantity stored (Q)--necessary to determine the supply impact of that particular type of fuel.

The variables necessary for the analysis portion of this study which are derived from the above parameters are:

1. Time (T)--the dependent variable of the analysis procedure of this study which indicates the maximum length of time an ALC can operate on emergency power under a curtailment of commercially supplied electrical power and petroleum fuels.

2. Fuel consumption rate (R)--an independent variable used in the analysis procedure of this study.

3. Fuel supply (S)--an independent variable used in the analysis procedure of this study.

4. Fuel tank capacity (F)--an independent variable used in the analysis procedure of this study.

Obviously, there are other variables that could affect the ability of an ALC to meet its critical operating requirements. The objective of this study, however, is to isolate only the effects of emergency fuel supplies on the ALC's ability to maintain critical operations. Therefore, several assumptions must be made concerning other factors which may affect this ability. First, it is assumed that sufficient maintenance and support personnel and equipment exist to keep all generators operating. Second, the requirements for emergency power generation in AFLC are, in the worst possible case, based on the necessity to maintain critical operations "during a wartime scenario in which AFLC installations must support overseas operations [20:1]." The 1979 AFLC study which outlined the requirement for emergency power based upon a wartime scenario also required the Air Logistics Centers to determine if generators were being used to support facilities not required during a wartime scenario, and if any facilities critical to operations during a wartime scenario were not being supported with emergency power. Though no facilities currently being supported with emergency generators were identified as being unnecessary during a wartime scenario, additional critical facilities were identified which were not being supported with emergency power (1). All existing emergency generators then are apparently required to support critical operations during a wartime scenario. Since additional generators will be installed in the future to support those critical facilities currently without emergency power, this study will also include the effect of these additional generators on the length of time the ALCs can maintain critical operations. Further, in the absence of restrictions or operating limitations to the contrary, it is assumed that implicit in a wartime scenario is the demand for continuous support from the ALC. Operationalizing this assumption for the purpose of this study requires examination of emergency generator fuel supplies under conditions of continuous, seven-day-a-week, twenty-four-hour-a-day operation. Consequently, the maximum length of time that the ALCs can maintain critical operations, for the purpose of this study and under the assumptions just outlined, is the maximum length of time that all existing and proposed emergency generators can operate on the ALC's supply of emergency fuel.

Data Collection

The data collection effort is designed to provide information regarding the measurement parameters contained in the summary list of parameters. With minor exceptions, this information will also essentially answer the first three research questions which seek information required to determine the value of the dependent variable, time, in the data analysis section.

For each Air Logistics Center, the data required are divided into two major areas--emergency power systems and emergency fuel storage tanks. Seven different parameters are required for each power system, and two parameters are required for each fuel storage tank.

Much of the information regarding both power systems and fuel storage tanks can be obtained from each Air Logistics Center in the form of Annexes to the Civil Engineering Base Recovery Plan (required by AFR 93-2), which is a contingency plan used to facilitate and expedite restoration of installation operations following a variety of potential disasters.

Information regarding the following parameters is located in Annex M, "Alternate or Emergency Power Sources and Lighting Systems:"

1. Each Emergency Power System
2. Each System's Power Output Rating
3. Each System's Fuel Type
4. Each System's Associated Facility
5. The Manufacturer/Model of Each System

The specific format for Annex M is outlined in AFR 93-2, and the Annex contains a complete list of all emergency generators on the installation, and certain information about each generator, not all of which is required by this study. The information on each generator in the Annex is listed in the following format:

1. Priority of Recovery
2. Location
3. Description (Manufacturer/Model)

4. Condition
5. Size (Kw)
6. Fuel (Type)
7. Operation (Manual/Automatic)
8. Approximate Running Time

The associated facility for each generator is determined by its location. The power output rating for each generator corresponds to the size in kilowatts listed in the Annex. The fuel type for each generator and the manufacturer/model are specifically listed.

Since the Base Recovery Plans are usually reaccomplished only yearly, the accuracy and currency of the information in the plans will be verified by examining, for each base, the Generator Status Chart, which "has data on each backup and standby generator maintained by Base Civil Engineering [23:p.2-3]." The format for this chart is located in AFR 85-1. Continuously maintained by the electrical power production shop, the chart includes the following information of interest:

1. Priority
2. Location
3. Manufacturer
4. Kw Rating
5. Maximum Running Time

Notice that both Annex M of the Base Recovery Plan and the Generator Status Chart provide information on generator running times. Though approximate or maximum running time could be an indirect indicator of both fuel tank capacity and fuel consumption rate, the regulations do not specify a method of computing running time, nor is running time specifically defined in terms of the hours per day that the generators would be operating. The running time in days of a continuously operating generator will obviously be less than the running time in days of the same generator operating only eight hours per day. Consequently, information regarding the specific fuel consumption rates for each emergency power system can be obtained from the manufacturer's technical specifications, which are available from the plant engineering service of the Information Handling Services company. The fuel consumption rate depends upon the manufacturer's model, the type of system, and the system output power rating. The fuel tank capacities for each power system can be obtained from the power production shop at each installation.

In addition to emergency power systems already installed at the ALCs, this study examines the impact of proposed emergency power systems on the length of time the ALCs can maintain critical operations. Information on the parameters for proposed systems can be obtained from the AFLC directorate of engineering in the form of the current Military Construction Project Data for the Command. The format for this data is DD Form 1391, which contains information regarding only required output power ratings and associated facilities. Fortunately, other parameters can be estimated using a USAF Aeropropulsion Laboratory study of Air Force Ground Power Requirements (5). This study provides average values for the required parameters based on the power system type and power output rating. The majority of emergency power systems use diesel engine generators fueled by No. 2 distillate oil, and an assumption for the thesis is that proposed emergency power systems will be of the diesel engine generator type.

Information regarding emergency fuel storage tanks is contained in Annex P of the Base Recovery Plan. This annex, entitled "POL Storage, Distribution and Emergency Backup," describes "the various POL systems including storage capacity, location of tanks and distribution system, and source of emergency stocks [21:35]."

Data Analysis

Recall that the dependent and independent variables are, respectively, time (T), fuel consumption rate (R), fuel tank capacity (F), and fuel stock allocation (S). For each emergency generator the dependent variable, time, is related to the independent variables by the following simple linear equation:

$$T=F/R+S/R$$

For each generator, the values of the independent variables, F and R, are known after completion of the data collection procedure, and they become constants in the equation. If F/R is defined as equal to constant B, and 1/R is defined as equal to the constant M, the equation reduces to what is easily recognized as a standard linear equation form:

$$T=MS+B$$

Thus, with a known fuel tank capacity and fuel consumption rate, the length of time a generator can operate is dependent upon the quantity of fuel allocated to it from the total additional emergency fuel stocks (corresponding to the type of fuel used in the system).

If an installation has an N number of generators using a specific fuel type, the following set of simultaneous equations describes the relationships between time and allocated fuel stocks:

$$\begin{aligned} T_1 &= M_1 S_1 + B_1 \\ T_2 &= M_2 S_2 + B_2 \\ T_3 &= M_3 S_3 + B_3 \\ &\vdots \\ T_N &= M_N S_N + B_N \end{aligned}$$

where $B_i = F_i/R_i$, and $M_i = 1/R_i$, $i=1$ to N.

Since all generators will be required to operate the same total length of time,

$$T_1 = T_2 = T_3 = . \ . \ . = T_N$$

Summing the N simultaneous equations yields:

$$NT = (M_1S_1+B_1) + (M_2S_2+B_2)$$
$$+ (M_3S_3+B_3) + . \ . \ . + (M_NS_N+B_N)$$

or

$$T = \frac{M_1S_1}{N} + \frac{M_2S_2}{N} + \frac{M_3S_3}{N} + . \ . \ . + \frac{M_NS_N}{N}$$
$$+ \frac{B_1}{N} + \frac{B_2}{N} + \frac{B_3}{N} + . \ . \ . + \frac{B_N}{N}$$

Let:

$$\frac{B_1}{N} + \frac{B_2}{N} + \frac{B_3}{N} + . \ . \ . + \frac{B_N}{N} = K$$

Then:

$$T = \frac{M_1S_1}{N} + \frac{M_2S_2}{N} + \frac{M_3S_3}{N} + . \ . \ . + \frac{M_NS_N}{N} + K$$

or

$$R-K = \frac{M_1S_1}{N} + \frac{M_2S_2}{N} + \frac{M_3S_3}{N} + . \ . \ . + \frac{M_NS_N}{N}$$

Since K is a constant, maximizing the right-hand side of the equation will yield the maximum time T, when K is again added to the right-hand side.

Let a variable Z=T-K. Then, also,

$$Z = \frac{M_1S_1}{N} + \frac{M_2S_2}{N} + \frac{M_3S_3}{N} + \ldots \frac{M_NS_N}{N}$$

This equation is in the standard form for solution by the linear programming solution technique known as "Simplex." This is a method for determining the optimal solution to a set of simultaneous linear equations with equality or inequality constraints. In this case, the maximum value of Z is required, subject to the constraint imposed by the finite quantity of emergency fuel at each installation.

The sum of the individual fuel allocations to each generator from emergency fuel stocks cannot exceed the total emergency fuel quantities stored on the installation, or:

$$S_1 + S_2 + S_3 + \ldots + S_N \leq S_t,$$

where S_t represents the total available emergency fuel stocks. S_t is determined by summing the quantities of each individual emergency fuel tank on base. For L fuel tanks,

$$S_t = Q_1 + Q_2 + Q_3 + \ldots + Q_L,$$

where Q is the quantity of fuel stored in each tank.

The fact that all generators are required to operate the same length of time imposes additional constraints on the system.

Since

$$T_1 = T_2 = T_3 \ . \ . \ . = T_N,$$

and

$$T_i = M_i S_i + B_i \qquad i = 1 \text{ to } N,$$

then

$$M_1 S_1 + B_1 = M_2 S_2 + B_2 = M_3 S_3 + B_3$$
$$= \ . \ . \ . = M_S S_N + B_N.$$

The following is a convenient method for expressing the above equality in a manner suitable for linear programming: Since

$$M_1 S_1 + B_1 = M_2 S_2 + B_2$$

then

$$M_1 S_1 - M_2 S_2 = B_2 - B_1$$

which is an equality constraint requiring that $T_1 = T_2$. Likewise,

$$M_2 S_2 - M_3 S_3 = B_3 - B_2$$

or

$$T_2 = T_3.$$

The general expression for the set of N-1 constraints required to ensure that all the times are equal is:

$$M_i S_i - M_{i+1} S_{i+1} = B_{i+1} - B_i \qquad i=1 \text{ to } N-1.$$

These constraints are generally all that is required to guarantee a feasible solution, except for one specific case. The case occurs when the total quantity of emergency fuel to be allocated is not sufficiently large to ensure that the maximum time, T, will be greater than the time that an individual generator can operate on its attached fuel tank alone. The equality constraints then force one or more of the allocations, S, to be negative, as the system tries to draw fuel from the generator with excess fuel. Since Simplex requires the variables to be greater than zero, the solution is infeasible. Elimination of the generator with excess capacity from the system will allow the Simplex method to optimally allocate the emergency fuel to the remaining generators.

The solution to the problem by the Simplex method will reveal the maximum length of time the generators will operate and the quantities of fuel which should be allocated to each specific generator to attain that maximum. Once the value of Z is maximized, the maximum time, T, is determined by adding the constant K to the value of Z.

Since:

$$Z=T-K$$

Then:

$$T_{max}=Z+K$$

The equation to be maximized, called the objective function, and the constraints are summarized below:

Objective Function:

$$Z = \frac{M_1S_1}{N} + \frac{M_2S_2}{N} + \frac{M_3S_3}{N} + \cdots + \frac{M_NS_N}{N}$$

Constraints:

$$S_1 + S_2 + S_3 + \cdots + S_N \leq S_t$$

$$S_1, S_2, S_3, \ldots, S_N \geq 0$$

$$M_iS_i - M_{i+1}S_{i+1} = B_{i+1} - B_i \quad i = 1 \text{ to } N-1$$

A separate Simplex problem must be solved for each type of fuel used by emergency power systems at each Air Logistics Center. With five Air Logistics Centers and possibly two or three different fuel types, ten or fifteen Simplex problems must be solved. These Simplex problems were solved using a linear programming computer code known as the Honeywell LP600 Linear Programming Package. An example problem illustrating the validity of the analysis procedure is explained in Appendix P.

The maximum length of time the generators can operate will most likely be different for each type of fuel. Since the operation of all generators is necessary to meet an installation's critical operating requirements, the maximum length of time these requirements can be met will be limited by the type of fuel which is exhausted first. In other words, given two fuel types, f_1 and f_2, where $T_{max}(f_1) < T_{max}(f_2)$, the maximum length of time that critical operating requirements can be satisfied at that installation will be $T_{max}(f_1)$.

Though the specific objective of the thesis is to determine the maximum length of time the ALCs can operate using emergency generators and emergency fuel stocks, this maximum is dependent upon the proper allocation of the fuel stocks to the generators. Consequently, each allocation can be expressed in terms of the number of times each generator will be completely filled, and the number of gallons of fuel to be pumped into the generator tank the final time it is refueled. This is determined by dividing each allocation, S, by the associated fuel tank capacity, and expressing the remainder in gallons. A generator allocated 25 gallons, for example, and having a 10-gallon fuel tank, would be refilled completely twice, and would receive a half tank, or 5 gallons, on the final refueling.

Completion of the previously outlined analysis for each Air Logistics Center successfully answers the fourth research question, and fulfills the thesis objective, which was to determine the maximum length of time the Air Logistics Centers could operate using emergency power during a curtailment of electrical power and petroleum fuels.

Summary of Assumptions

1. All information obtained from valid, official Air Force sources is accurate.

2. Commercial sources of emergency power are not available during a supply curtailment.

3. Proposed emergency power systems will be diesel engine generator type.

4. Emergency power systems will be operating continuously during a wartime scenario.

5. All emergency power systems must be operating in order for an installation to meet its minimum critical operating requirements.

6. Maintenance and support, parts and services are adequate to maintain continuous generator operation.

CHAPTER III

DATA COLLECTION

Introduction

This chapter outlines particulars of the actual collection of the program input data specified in Chapter II. Although the actual collection effort closely follows the proposed collection plan, variations in the way that each particular ALC maintained and reported the needed data necessitated a particular approach to data retrieval in each case. This was precipitated by the facts that:

1. In most cases, Annex M of the base recovery plans did not contain all data required by AFR 93-2.

2. Annex P of each of the base recovery plans did not present fuel data in a manner which permitted the determination of the amounts of fuel allocated specifically to emergency back-up power generation.

The effect of the above general circumstances on the actual retrieval of the generator and fuel data from each particular ALC will be detailed in the respective following sections of this chapter. An additional circumstance which became evident during the actual data collection effort was that the study could be condensed to consider only those generators powered by diesel fuel without impacting on the results. For each of the ALCs in question, the number and size of the gasoline powered generators were so limited as to make it intuitive that their inclusion would not be a controlling factor in the study.

Generator Data

General

A summary listing of the generator data for each ALC is attached as Appendix A of this study. Generators identified by an asterisk in this appendix are those which an AFLC study (1) has indicated are necessary to permit that particular ALC to meet its minimum operating requirements, but that are only proposed at the present time. Data for these generators at each ALC were obtained from DD Forms 1391 of the FY 82 Military Construction Program (2:6,17, 24,36,49) for Hill AFB, Kelly AFB, McClellan AFB, Robins AFB, and Tinker AFB, respectively. As described in Chapter II of this study, these DD Forms 1391 include only required output power rating and associated facility. Fuel consumption rate figures for these proposed generators were determined by interpolation from a chart of fuel consumption versus output power for continuous operation in an Air Force Aeropropulsion Laboratory technical report (5:108). These fuel consumption figures were compared with actual manufacturer data obtained through the Information Handling Services company (10) for generators of corresponding output power and were found to be very highly correlated, indicating that the interpolated values are reliable predictors of fuel consumption rates for generators of unknown make and model. Generator fuel tank capacities were also not specified for the proposed generators, making it necessary to assume a value for this input parameter for each of the proposed generators. The "USAF Terrestrial Energy Study" accomplished by Air Force Aeropropulsion Laboratory specifies a "design-to" target of a five-day fuel capacity for diesel power systems of 10 MW or less (5:100). As the proposed generators at all five ALCs fall into this category, the generator fuel tank size of each was selected as the quantity which permitted that particular generator to run five days under conditions of continuous operation. This value is simply the interpolated hourly fuel consumption rate multiplied by 120 hours (5 days). These tank capacities and running times are not inconsistent with those of many generators already in place at the ALCs.

<u>Data on Existing Generators</u>

This section identifies the source of the input data by ALC, for the parameters outlined in Chapter II with the exception of fuel consumption rates. As earlier described, the fuel consumption rate of each generator is determined by generator specifications and not the running times listed in the base recovery plans of the various ALCs.

Therefore, consumption rate determination will be detailed in a separate following section.

Hill AFB. Data on the parameters of facility, manufacturer, power rating, fuel type, and tank capacity of installed generators were obtained from the base recovery plan (12:M-1 to M-3). Generator model numbers and tank capacities of mobile generators were obtained from the generator status board and/or records at Hill AFB (16). Base recovery plan data were also confirmed or adjusted as necessary based on these contacts (16).

Kelly AFB. Data on the parameters of facility, power rating, fuel type, and tank capacity were obtained from the base recovery plan (13:M-1). Manufacturer and model number, as well as corroboration of base recovery plan data were obtained via telephone communication (9).

McClellan AFB. Data on the parameters of the facility and power rating only were available from the base recovery plan (14:64-65). Data on manufacturer, model number, fuel type, and tank capacity for each generator was obtained from records and the generator status board at McClellan AFB (3). Contact with personnel at McClellan AFB was also used to verify all data (3).

Robins AFB. All necessary data excepting tank size were available in the base recovery plan (15:M-1-1 to M-2-1).

Data corroboration and tank size were obtained by telephone communication with Robins AFB personnel (11).

Tinker AFB. The base recovery plan for Tinker AFB was under revision and unavailable at the time of the data collection effort. All data were collected via telephone contact with Tinker AFB personnel (18).

Fuel Consumption Rate Determination

Once the parameters of manufacturer (or make), model number, and output power were obtained, fuel consumption rate for any given generator was determined in one of three ways:

1. Generators identified with MB series model numbers are federally stocked generators made by numerous different manufacturers, even for a given particular output rating. Fuel consumption rates for these generators are an adopted standard to insure consistency in planning, and were obtained directly from Air Force records at the ALCs (3; 9; 11; 16; 18). These generators are identified in Appendix A by their associated MB series model numbers.

2. For generators of known make and model, a search of Data Control Services Plant Engineering Series microfilm records was made; where the exact make and model could be located, fuel consumption rate data were taken directly from these records (10). Generators where the data were

obtained in this manner are identified in Appendix A by an (a) following the fuel consumption rate figure.

3. Some generators of known make and model were not locatable through Plant Engineering Series microfilm records. In this instance, the fuel consumption rate used was one of the following:

a. The average rate of all generators of that particular output power by that particular manufacturer, as determined from VSMF Plant Engineering Series microfilm (10).

b. Where less than two generators of the same output rating and manufacturer were locatable, the fuel rate used was one which was equal to the rate of the one generator of that power output that was found.

c. If no generator for that output and by that manufacturer was locatable, the fuel consumption rate used was the average of all generators of the particular output found in the VSMF Plant Engineering Series microfilm records, regardless of manufacturer.

To ensure consistency and the most accurate data possible, this procedure was followed in the order in which it was just described. Generators for which fuel consumption rate data were found in this manner are identified by a (b) following their respective fuel consumption rate figure in Appendix A.

Note that some generators in Appendix A are identified by the same generator number. Those generators with the same number share a common fuel tank, and will share the fuel allocation identified by the linear programming analysis. Also, since the generators share a common fuel tank, the consumption rate associated with that fuel tank and used in the linear program is simply the sum of the consumption rates of all generators sharing that tank.

Fuel Availability Data

As previously stated, Annexes P of the base recovery plans did not present fuel data in a manner which permitted the determination of exact amounts of fuel specifically allocated to emergency back-up power generation. These annexes listed total quantities of fuel from which fuel for back-up power generation was drawn. Therefore, it was necessary to deviate from the original data collection plan specified in Chapter II to obtain the needed data. A proper determination of fuel quantities available for emergency power generation was obtained through the Command Fuels Office at Headquarters AFLC (25). Data needed from this source was in the form of total diesel fuel available and a daily demand rate (DDR) for its use at each ALC. In this form, these fuel figures could be incorporated into the linear programs utilized in this study by treating the daily demand rate as a surrogate generator or fuel user and treating the fuel available as a source from which all emergency power generators and the surrogate generator at each ALC could draw. The actual data obtained was in the form of barrels of fuel available and daily demand rate expressed in barrels per day. This data is presented in tabulated form for each ALC on the last page of Appendix A. For incorporation into the linear program package used in this study, the data were converted to gallons and gallon per hour rates, as appropriate, to make them consistent with all other generator data. The standard conversion of 42 gallons per barrel was used in these conversions.

CHAPTER IV

RESULTS OF DATA ANALYSIS

Introduction

This chapter discusses the results of the LP600 programs for each Air Logistics Center. The LP600 programs and selected output products for each ALC are contained in the appendices. Prior to discussing the individual results for each installation, the slight change in the analysis procedure resulting from the lack of specifically identified emergency fuel stocks must be discussed. Recall from Chapter III, Data Collection, that information was obtained on the maximum total amount of diesel fuel available at an installation and also the average daily demand rate for diesel fuel at the installation. The total amount of diesel fuel available must supply both the normal requirements of the installation, as represented by the daily demand rate, as well as the added requirements of the emergency generators during an electrical power supply curtailment. Consequently, for the purpose of developing the objective function, daily demand rate can be considered an analogue of the fuel consumption rate associated with each emergency generator. Including the daily demand rate for the installation in the objective function and in the time equality constraints allows the construction of a fuel supply constraint which has as its limiting parameter the total amount of diesel fuel available on the installation, rather than an amount specifically set aside as an emergency fuel stock. This is a more realistic approximation of the situation as it actually exists at the ALCs, regardless of the implication in the format for Annex P of the Base Recovery Plan that separate emergency fuel stocks for generators do exist.

The problem of one or more individual generators being able to run longer on the attached fuel tanks than the system as a whole can run on the total amount of additional diesel fuel available was discussed in Chapter II. Recall that the Simplex problem is infeasible when this situation exists, and the offending generators must be eliminated from the system before an optimal solution can be found. Since the coefficients of the objective function and the constant K are based, in part, on the number of generators in the system, elimination of generators from the system would seem to require the computation of a new set of coefficients and a new constant each time generators are eliminated. The coefficients, however, maintain the same relative proportions to each other, regardless of the number of generators in the system, and the proper optimal solution can be determined simply by multiplying the optimal value on the computer output by a ratio of the original number of generators in the system, and the number of generators remaining in the system when the Simplex problem finally becomes feasible.

For a system of N generators the objective function is:

$$Z = \frac{M_1S_1}{N} + \frac{M_2S_2}{N} + \frac{M_3S_3}{N} + \ . \ . \ . + \frac{M_NS_N}{N}$$

If three generators must be eliminated to produce a feasible problem, a system of N-3 generators results. Rather than adjusting each coefficient prior to maximizing the objective function, the computer program is run with the original coefficients and Z is adjusted to account for the change in the number of generators in the system.

The objective function maximized will be:

$$Z = \frac{M_1S_1}{N} + \frac{M_2S_2}{N} + \frac{M_3S_3}{N} + \ . \ . \ . + \frac{M_{N-3}S_{N-3}}{N}$$

The resulting maximized Z is adjusted by a ratio of $\frac{N}{N-3}$.

$$Z_{adjusted} = \frac{ZN}{N-3}$$

$$= \frac{M_1S_1N}{N(N-3)} + \frac{M_2S_2N}{N(N-3)} + \frac{M_3S_3N}{N(N-3)} + \ldots + \frac{M_{N-3}S_{N-3}N}{N(N-3)}$$

$$= \frac{M_1S_1}{N-3} + \frac{M_2S_2}{N-3} + \frac{M_3S_3}{N-3} + \ldots \ \frac{M_{N-3}S_{N-3}}{N-3}$$

Thus the adjusted Z is the correct optimal value for a system of N-3 generators when the objective function coefficients are not changed each time a generator is eliminated from the system. Examination of the LP600 input programs in Appendix B will illustrate the wisdom of adjusting Z rather than adjusting individual coefficients. The constant K is also computed based on the number of generators remaining in the system when the problem becomes feasible.

Analysis of Robins Air Force Base

The LP600 computer output for Robins AFB is contained in Appendix C. The first page illustrates the 28 successive iterations required to obtain the optimal solution for the objective function. The optimal solution is the value in the functional column at the final iteration. The next page illustrates the slack values in the constraints and the original right-hand-side values for the set of linear equations. Since the only actual resource constraint is that constraint associated with the total amount of fuel available, the program should continue increasing the value of the objective function until the fuel is completely exhausted. Complete allocation of the available fuel is indicated by a slack of zero in the fuel constraint row. The time constraints, since they are equality constraints, also have zero slack. The fuel quantities allocated to each generator are located in the column marked "X-value."

The Robins AFB problem was feasible with all generators in the system, and no adjustment of Z was necessary. From the LP600 computer output:

$$Z = 232.6$$

Recall that the constant $K = \Sigma \frac{F_i}{R_i N}$ $i = 1$ to N.

Or: $$K = 90.3$$

Solve for T_{max}: $$T_{max} = Z + K$$

$$T_{max} = 232.6 + 90.3$$

$$= 322.9 \text{ Hours}$$

$$= 13.45 \text{ Days}$$

Based on a maximum total quantity of diesel fuel of 101,976 gallons, Robins AFB can operate on emergency power for 13.45 days.

Analysis of Hill Air Force Base

The Hill AFB problem required the elimination of two generators for the problem to be feasible. Both the original program and the modified program are contained in the appendices. Examination of the original program output in Appendix E reveals that all generators in the system were not included in the basis, and thus an optimal solution was not found. The optimal value for Z from the adjusted program output in Appendix F is:

$$Z = 336.1$$

This value of Z must be adjusted by a ratio to account for the change in the number of generators included in the final computer program. The original N was 47. Since two generators were eliminated from the system, the proper ratio is 47/45.

$$Z_{adj.} = Z(47/45)$$

$$= (336.1)(47/45)$$

$$= 351$$

$$K = 100.4$$

$$T_{max} = Z_{adj.} + K$$

$$= 351 + 100.4$$

$$= 451.4 \text{ Hours}$$

$$= 18.8 \text{ Days}$$

Based on a maximum total quantity of diesel fuel of 215,712 gallons, Hill AFB can operate on emergency power for 18.8 days. Since the generators eliminated from the system can operate considerably longer than 18.8 days on their attached fuel tanks, all other generators and the air base would run out of fuel before these two generators. Nevertheless, since all generators are required in order to meet minimum critical operating requirements, 18.8 days is the limiting value.

Analysis of McClellan Air Force Base

Since the McClellan AFB problem required the elimination of generators for a feasible problem, the original and adjusted programs are included in the appendices. The optimal solution from the adjusted program (Appendix I) also must be adjusted for the changed value of N.

$$
\begin{aligned}
Z &= 278.7 \\
Z_{adj.} &= 278.7(36/31) \\
&= 323.7 \\
K &= 55 \\
T_{max} &= Z_{adj.} + K \\
&= 278.7 \text{ Hours} \\
&= 15.8 \text{ Days}
\end{aligned}
$$

Though some generators can operate longer than 15.8 days, with a total quantity of diesel fuel of 122,976 gallons, the installation can operate all critical facilities on emergency power a maximum of 15.8 days.

Analysis of Tinker Air Force Base

Tinker AFB was especially limited by the small quantity of diesel fuel available, 23436 gallons, and 15 generators were eliminated from the system to produce a feasible problem. The optimal value for Z is obtained from the adjusted computer program output in Appendix L.

$$Z = 58.9$$

$$Z_{adj.} = 28.9(37/22)$$

$$= 99.1$$

$$K = 29.9$$

$$T_{max} = Z_{adj.} + K$$

$$= 129 \text{ Hours}$$

$$= 5.4 \text{ Days}$$

To produce a feasible problem, five proposed generators with an assumed running time of 120 hours were eliminated from the system. From previous analysis it seems reasonable to include these generators in the system, but including all five produces an infeasible problem. To include only a few of these five generators in the system would produce a maximum time somewhat less than 129 hours, but still greater than 120 hours. Since these five generators are not yet in existence, 129 hours seems a reasonable enough figure for the maximum length of time Tinker AFB can operate on emergency power with 23,436 gallons of diesel fuel.

Analysis of Kelly Air Force Base

The Kelly AFB problem also required the elimination of numerous generators from the system for a feasible solution. The optimal value for Z is obtained from the adjusted computer program output in Appendix O.

$$Z = 29.2$$

$$Z_{adj.} = 29.2(38/16)$$

$$= 69.3$$

$$K = 39.7$$

$$T_{max} = Z_{adj.} + K$$

$$= 109 \text{ Hours}$$

$$= 4.5 \text{ Days}$$

At Kelly AFB, more than half the generators will run longer on attached fuel tanks than the system will run on the additional diesel fuel available. Based on 10,290 gallons of diesel fuel, the base can meet its minimum critical operating requirements for 4.5 days.

Discussion of Results

The results of the analyses are summarized in Table 1.

TABLE 1

SUMMARY OF RESULTS

ALC	Total # of Generators	# of Generators in Linear Program	Fuel Available (Gallons)	T_{max} (Days)
Robins	28	28	101,976	13.45
Hill	47	45	215,712	18.8
McClellan	36	31	122,976	15.8
Tinker	37	22	23,436	5.4
Kelly	38	16	10,290	4.5

The individual fuel allocations to each generator can be obtained from the LP600 output products in the appendices. Using these allocations, expressed in gallons, and the fuel tank sizes in Appendix A, the number of complete fuel tank refills for each generator can be determined using the procedure outlined in Chapter II.

The determination of the maximum length of time that an ALC can operate on emergency power is based on the maximum total quantity of diesel fuel authorized for storage at the ALC. This maximum will be reached only on those occasions when the base has a delivery of diesel fuel from a commercial supplier. Once a delivery is made, the total quantity of fuel available for use during an emergency will decrease each day by an amount approximated by the daily demand rate. Just prior to a new delivery of diesel fuel, depending upon the diesel fuel inventory reorder point at each base, the maximum length of time the base can operate on emergency power will be considerably less than the optimum values listed in Table 1.

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary

The uncertainty of the availability of future supplies of petroleum has raised the possibility that a future electrical power curtailment could be accompanied by a simultaneous curtailment of petroleum fuel supplies. During such curtailments the ability of the ALCs to accomplish the essential operations required by a wartime scenario may depend upon the use of emergency back-up generators to provide electrical power to critical facilities. Using information about the back-up generators at each ALC and the quantities of fuel likely to be available for generator use during a supply curtailment, this study determined the maximum length of time each ALC can continue to meet its minimum critical operating requirements during a complete curtailment of commercially supplied electrical power and petroleum fuels.

Conclusion

The results of the linear programming analysis of the information acquired from each ALC indicate that a long-term curtailment of commercially supplied electrical power and petroleum fuels may have a significant adverse impact on an ALC's ability to meet its critical operating requirements during a wartime scenario requiring continuous support from the ALC. The maximum length of time the ALCs could operate on emergency power varies from about 4.5 days at Kelly AFB to almost 19 days at Hill AFB.

Whether the results of the analysis are a basis for concern depends upon the extent to which the underlying assumptions of this study accurately reflect the situation as it will actually exist during supply curtailments and a wartime scenario, and whether the probability of the simultaneous occurrence of electrical power and petroleum curtailments and a wartime scenario is great enough to warrant any economic expenditures necessary to prepare for such an eventuality. The major assumptions concerning the operation of the emergency generators during a wartime scenario were that all generators must function to successfully meet critical operating requirements and that the generators must run continuously until restoration of commercial electrical power. Relaxation of either of these assumptions would increase somewhat the length of time the installation could operate on emergency power. At Hill AFB, for example, if all generators were operated an average of 16 hours per day rather than 24, the maximum length of time the installation could operate on emergency power would increase from about 19 days to 28 days. Likewise, if critical operations could be maintained without using all the generators currently viewed as essential to those operations, the maximum time the installation could operate on emergency power could also be increased.

An implicit assumption for this study is that the emergency power generators will not have access to fuels specifically allocated for other uses. Since the overwhelming majority of emergency generators burn a high grade distillate fuel oil, the possibility exists that other similar petroleum based fuels could be used in an emergency to extend the operating time of the generators. The heating oil used for industrial steam production and facility heating at some installations is similar to the distillate fuel oil used in diesel generators, but contains more impurities. If heating oil could be diverted for use in emergency generators, the maximum length of time that an installation could operate on emergency power would increase an amount commensurate with the quantity of fuel diverted.

Another implicit assumption of this study is that it is generally impractical to remove fuel from the attached fuel tank of a long-running generator and use it to fuel a generator with a short running time. Any fuel which could be removed from generators with extremely large fuel tanks and used in other generators with smaller tanks would, of course, increase somewhat the total length of time the system of generators could be operated. Optimally reallocating the total amount of fuel available, including that in the individual generator fuel tanks, could increase the length of time the generators could operate to the upper limit which is equal to the total amount of fuel available divided by the sum of the individual fuel consumption rates of all the generators.

The practical problems associated with optimally allocating the available fuel supplies to the emergency generators were not addressed by the LP600 computer analysis. The computer program assumes that each generator will be automatically and instantaneously refueled each time its fuel tank is exhausted, and the appropriate amount of fuel will be pumped into each tank to guarantee the generator system will operate the maximum time. In reality, the refueling of the generators will be constrained by the availability of fuel trucks and personnel, and the effectiveness of the refueling schedule. Determining when individual generators will exhaust their individual fuel tanks and refueling the generators in a timely manner will be a major scheduling problem, especially during the accelerated pace of a wartime scenario. Consequently, the maximum times determined by the computer analysis may be somewhat longer than the maximum times the bases could realistically be expected to operate considering the practical logistics problems associated with generator refueling.

The possibility of simultaneous curtailments of electrical power and petroleum fuel supplies and a wartime scenario may seem rather remote, but preparation for highly improbable eventualities has become almost a necessity in a world in which the occurrence of improbable and often completely unexpected events has become almost routine. Consequently, adequate preparation for the possible curtailment of electrical power and petroleum fuel supplies at the Air Logistics Centers is probably a reasonably prudent stragegy, especially in light of the fact that the ALCs will have an integral role in insuring that American forces are provided adequate logistical support during any future armed conflict.

Recommendations

The Air Logistics Centers should remove most of the uncertainty regarding their ability to meet critical operating requirements during a curtailment of commercially supplied electrical power and petroleum fuels by determining the quantity of fuel required to operate the emergency generators during the specific wartime scenarios which the Centers will be required to support, and by maintaining that quantity of fuel as an emergency stock on the installation.

To insure that only the minimum amount of fuel necessary to maintain essential operations is stored on the installation, each Air Logistics Center should:

1. Determine the minimum critical operations necessary during specific wartime scenarios and the minimum facilities required to support those operations.

2. Determine the number of hours per day and the expected number of days generators supporting the critical facilities will be required to operate during specific wartime scenarios.

3. Based upon the generator fuel consumption rate and the quantity of fuel stored in each generator's attached fuel tank, determine the quantity of additional fuel required to operate the emergency generators for the projected time period.

4. Determine the feasibility of using alternate fuels, such as heating oil, in emergency generators for an extended period of time.

5. Insure that the necessary quantities of primary or appropriate alternate fuels are maintained as either separate emergency fuel stocks, or as additional safety stocks in the standard base fuel supply system.

APPENDICES

APPENDIX A

ALC GENERATOR AND FUEL DATA

Hill AFB Generator Data

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
1	221	Enterprise	DSM36	350	2,500	28.0(a)
2	3		MB-16	100	1,500	8.8
3	10	Waukesha	6NKDBSEU	150	2,000	12.5(a)
4	771		MB-18	30	500	3.3
5	768		MB-18	30	950	3.3
6	10762		MB-17	60	900	5.1
7	799		MB-18	30	500	3.3
8	776	Kohler		45	1,000	4.0(b)
9	598	Kohler		45	1,000	4.0(b)
10	11	Onan	ARS61PG	100	900	8.8(a)
11	1214		MB-17	60	1,050	5.1
12	9	Caterpillar	D-318	75	300	24.5(a)
13	774	Cummins	HT-6B1	75	1,000	6.5(a)
14	Pinedale	General Motors	5034-7101	30	250	3.3(a)
15	36	Detroit Diesel	1043700	75	70	6.5(b)
16	593		MB-18	30	500	3.3
17	1102		MB-15	150	1,260	13.5
18	2106		MB-19	15	26.5	2.5
19	260	Waukesha	VERBS	400	18,000	31.5(a)
20	1286	General Motors	RC	100	2,100	8.8(a)
21	Lt. Mtn.		MB-15	150	108	13.5
22	1310	Caterpillar	D-333	125		

(a) indicates fuel consumption rate obtained directly from manufacturer's data for that particular generator (see Chapter III).

(b) indicates fuel consumption rate obtained by a method other than specific manufacturer's data (see Chapter III).

Hill AFB Generator Data--Continued

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
23	575	Detroit Diesel	V-71	300	2,000	23.0(a)
24	519	Enterprise	DSM38	500	18,000	35.0(a)
25	2416A	Cummins	KTA1150G	350	2,000	29.0(a)
26	270		MB-16	100	1,000	8.8
27	1847		MB-18	30	500	3.3
28	11300	Allis Chalmers	7000	75	1,050	6.5(b)
29	11301	Caterpillar	D-330	100	2,100	8.8(a)
30	1309	Caterpillar	D-333	110	500	9.0(a)
31	1204	Allis Chalmers	7000	75	1,050	6.5(b)
32	32		MB-17	60	43	5.1
33	32		MB-15	150	108.5	13.5
34	11	Onan	ARS61PG	100	71.5	8.8(a)
35	32		MB-15	150	108.5	13.5
36	32		MB-18	30	26.5	3.3
37	32		MB-18	30	26.5	3.3
38	32		MB-19	15	21.0	2.5
39	32		MB-19	15	21.0	2.5
40	32		MB-16	100	71.5	8.8
41	Wendover		MB-15	150	108.5	13.5
42*	100			400	3,840	32.0
43*	845			350	3,360	28.0
44*	849			1000	9,600	80.0
45*	850			350	3,360	28.0
46*	900			800	7,680	64.0

* indicates proposed generators (see Chapter III).

Kelly AFB Generator Data

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
1	1610		MB-17	60	250	5.1
2	375	Waukesha	WDKDY	100	400	8.8(a)
3	1600	Allis Chalmers	DD 334	40	105	4.0(b)
4	1650	Stewart-Stevenson	6GD-100	100	250	8.8(b)
5	2000	General Motors	GM-100-D-18RR	75	200	6.5(a)
6	2000	General Motors	ATS-60-2	75	200	6.5(a)
7	2000		MB-15	100	1,500	8.8
8	1740		MB-18	25	300	3.3
9	171		MB-16	100	100	8.8
10	1420		MB-17	60	250	5.1
11	1420	Stewart-Stevenson	2GD-25	20	60	1.7(b)
12	1620	Caterpillar	34-12CAT	200	500	16.0(a)
13	809		MB-17	60	100	5.1
14	474	Onan	15RPJC3A	15	250	1.3(a)
15	1408		MB-19	15	250	2.5
16	1493	Stewart-Stevenson	2GD-35C	30	250	3.3(b)
17	1499		MB-18	30	500	3.3
18	811		MB-18	30	250	3.3
19	1160		MB-17	60	250	5.1
20	1625	Stewart-Stevenson	2GD-35C	20	250	1.7(b)
21	1674		MB-16	100	6,700	8.8
22	1674	Caterpillar	D-33069C	100	220	8.8(a)
23	2213	Stewart-Stevenson	3045C	30	500	3.3(b)
24	1630		MB-15	150	105	13.5
25*	Unspecified			25	240	2.0
26*	Unspecified			25	240	2.0
27*	1414			100	960	8.0
28*	1470			200	1,920	16.0

Kelly AFB Generator Data--Continued

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
29*	1523			50	480	4.0
30*	1534			50	480	4.0
31*	1534			50	480	4.0
32*	1534			50	480	4.0
33*	1534			50	480	4.0
34*	1534			200	1,920	16.0
35*	1534			200	1,920	16.0
36*	Unspecified			100	960	8.0
37*	1562			50	480	4.0

McClellan AFB Generator Data

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
1	200	Caterpillar	D-353-1A	300	8,000	24.5(a)
2	1099		MB-15	150	1,000	13.5
3	870	Ohio Numatic	B-3602	350	1,000	28.0(b)
4	702		MB-18	30	215	3.3
5	701		MB-A	15	250	2.5
6A	262B	White Superior	40-SX-8	440	20,000	34.0(b)
6B	262B	White Superior	40-SX-8	440		34.0(b)
6C	262B	White Superior	12Y-711B	200		16.5(b)
6D	262B	White Superior	40-SX-8	400		34.0(b)
6E	262B	General Motors	12U-711D	200		16.5(a)
7A	7	Baldwin-Lima Hamilton	606A	600	50,000	47.0(b)
7B	7	White Superior	60B-SX-8	650		51.0(b)
7C	7	Baldwin-Lima Hamilton	606A	600		47.0(b)
8A	4710	General Motors	16-567-D	1000	75,000	83.0(a)
8B	4710	General Motors	16-567-D	1000		83.0(a)
9	20		MB-17	60	2,500	5.1
10	617		MB-19	15	250	2.5
11	4131	General Motors	671	100	5,000	8.8(a)
12	1071		MB-17	60	43	5.1
13	635		MB-18	30	26	3.3
14	948		MB-19	15	21	2.5
15	1		MB-17	60	43	5.1
16A	7	Consolidated Diesel	76-0189	60	2,500	5.1(b)
16B	7	Consolidated Diesel	76-0189	60		5.1(b)

McClellan AFB Generator Data--Continued

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
17	6008	Onan	15-ORDJC-3R	15	500	1.3(a)
18	685		MB-17	60	43	5.1
19	329		MB-16	100	550	8.8
20	251N		MB-17	60	43	5.1
21	685		MB-16	100	70	8.8
22	685		MB-15	150	107	13.5
23	685		MB-16	100	70	8.8
24	685		MB-17	60	150	5.1
25	685		MB-16	100	70	8.8
26	685		MB-15	150	107	13.5
27	251S		MB-18	30	26	3.3
28	685		MB-17	60	43	5.1
29	685		MB-17	60	43	5.1
30	685	Consolidated Diesel	XME-D007A	100	70	8.8(b)
31	685		MB-15	150	107	13.5
32	1106		MB-17	60	43	5.1
33	21		MB-17	60	43	5.1
34	685	Consolidated Diesel	XME-D007A	100	70	8.8(b)
35*				1,000	9,600	80.0

Robins AFB Generator Data

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
1A	2	Pavid	J115PWH-D	115	1,000	9.8(b)
1B	2	Jeta	C010018	100		8.8(b)
2	11	General Motors	6903	60	250	5.1(a)
3A	12	Consolidated Diesel	4221	100	1,200	8.8(b)
3B	12	Caterpillar	3412	450		35.0(a)
4	14	Pavid	G15H3	15	250	1.3(b)
5	25	Onan	D18F6H4	18	150	1.7(a)
6	38	Caterpillar	D-330	60	1,000	5.1(a)
7	80	Pavid	J150WHD	15	300	1.3(b)
8A	107	Jeta	CD10018	100	59	8.8(b)
8B	107	Jeta	CD10018	100		8.8(b)
9	110	Caterpillar		200	250	16.0(b)
10	ILS#1	Pavid	G2581	25	50	3.0(b)
11	ILS#1	Pavid	G2581	25	50	3.0(b)
12	37		MB-17	60	1,000	5.1
13	78	Porter	4820	30	500	3.3(b)
14	210	Caterpillar	D-330	60	250	5.1(a)
15	214	Katolite	6NKDB	150	2,000	12.5(a)
16	225	Caterpillar	D-343	250	5,000	19.0(a)
17	263	Pavid	J35DWH-D	30	300	3.3(b)
18	272	Pavid	J65DWH-D	65	250	5.5(b)
19	376	Onan	150RDJ6	15	250	1.3(a)
20	377	John Deere	500DEE	50	250	4.5(b)
21	644		MB-15	150	250	13.5
22A	700	Katolite	D100MPZ4E	100	2,500	8.8(a)

Robins AFB Generator Data--Continued

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
22B	700	Katolite	D100MPZ4E	100	2,500	8.8(a)
23	54		MB-16	100	200	8.8
24	158	Caterpillar	D-330	60	250	5.1(a)
25	162		MB-16	60	250	5.1
26	177	Caterpillar	D-412	450	1,200	35.0(a)
27*	Unspecified			2615	25,104	209.2

Tinker AFB Generator Data

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
1A	3001	King Knight	12V71	200	20,000	16.0(b)
1B	3001	King Knight	12V71	200		16.0(b)
1C	3001	White Superior	40-SX-8	440		34.0(b)
1D	3001	White Superior	40-SX-8	440		34.0(b)
1E	3001	White Superior	40-SX-8	440		34.0(b)
2	240	Caterpillar		350	500	28.0(b)
3	Tacan	Eseco	135DK	30	275	3.3(b)
4	928	Kohler	20R0P61	20	287	1.7(a)
5	930	Kohler	D2300X188	25	287	3.0(a)
6	932	Kohler	125RCOP61	12.5	275	1.3(a)
7	935	Fermont	NHC-4-B1G	60	275	5.1(b)
8	1100	Fermont	NH200-B1G	100	500	8.8(b)
9	1111	Kohler	20ROP61	20	275	1.7(a)
10A	5802	Waukesha	148DKB	100	12,000	8.8(a)
10B	5802	Waukesha	148DKB	100		8.8(a)
11	260	Fermont	NH220-B1G	100	69.5	8.8(b)
12	4029	Fermont	NH220-B1G	100	500	8.8(b)
13	20288	Fermont	NRTO-6B1	150	107	13.5(b)
14	23702	Fermont	NRTO-6B	150	107	13.5(b)
15	23720	Fermont	NRTO-6B1G	150	107	13.5(b)
16	441	Fermont	D298ER	30	26.5	3.3(b)
17	435	Federal Electric	NHC-4-B1	60	155	5.1(b)
18A	284	Waukesha	F2896DS1U	400	10,000	31.5(a)
18B	284	Waukesha	L1616DSU	175		14.5(a)
19	1124	Fermont	NHC-4-B1G	60	300	5.1(b)
20	933	Katolite	D200X99	20	350	1.7(a)

Tinker AFB Generator Data--Continued

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
21	942	Katolite	D200X99	20	350	1.7(a)
22	487	Caterpillar	D-399C	500	3,500	35.0(a)
23	230	John Deere	42190F01	30	1,000	3.3(b)
24	2125	Pavid	D2300X207	30	12	3.3(b)
25A	3001E	Caterpillar	3406DI	210	20,000	16.5(a)
25B	2001E	Caterpillar	3406DI	210		16.5(a)
26	906	Pavid	D4800X127	75	250	19.0(b)
27	414	Fermont	NH-220-B1G	100	69.5	8.8(b)
28	414	Fermont	NH-220-B1G	100	69.5	8.8(b)
29	414	Fermont	NHC-4-B1G	60	43.5	5.1(b)
30	414	Fermont	D198ER	15	21	1.3(b)
31	414	Federal Electric	D298ER	30	26.5	3.3(b)
32*	260			300	2,880	24.0
33*	416			100	960	8.0
34*	506			1,000	9,600	80.0
35*	3001			1,000	9,600	80.0
36*	3001G			500	4,800	40.0

AFLC Fuel Availability Data

ALC	Diesel Fuel Available (BBLS)	Daily Demand Rate (BBLS/Day)
Hill AFB	5136	10.0
Kelly AFB	245	7.0
McClellan AFB	2928	3.0
Robins AFB	2428	10.0
Tinker AFB	558	39.0

APPENDIX B

ROBINS AFB INPUT PROGRAM

```
10##S,R(SL) :,8,16;;,16
15$:IDENT:WP1186, MOTT/NELSON THESIS
20$:USERID:80A053$KR79
25$:PROGRAM:RLHS
30$:LIMITS:10,39K,,5K
35$:PRMFL:H*,R,R,AF.LIB/LP.PAC
40$:REMOTE:SO,SL
45$:DISC:AA,A1,10R
50$:DISC:AB,A2,10R
55$:DISC:AC,A3,10R
60$:DISC:AD,A4,10R
65$:DISC:AE,A5,10R
70$:DATA:IN
75FILE:ELEC
80**** RUBINS AFB FUEL PLAN ****
85****                      ****
90**** CONSTRAINT MATRIX ****
95****                  ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S1(P)=1
110:,S2(P)=1
115:,S3(P)=1
120:,S4(P)=1
125:,S5(P)=1
130:,S6(P)=1
135:,S7(P)=1
140:,S8(P)=1
145:,S9(P)=1
150:,S10(P)=1
155:,S11(P)=1
160:,S12(P)=1
165:,S13(P)=1
170:,S14(P)=1
175:,S15(P)=1
180:,S16(P)=1
185:,S17(P)=1
190:,S18(P)=1
195:,S19(P)=1
200:,S20(P)=1
205:,S21(P)=1
210:,S22(P)=1
215:,S23(P)=1
220:,S24(P)=1
225:,S25(P)=1
230:,S26(P)=1
235:,S27(P)=1
240:,S28(P)=1
```

```
245**** TIME EQUALITY CONSTRAINTS ****
250MATRIX:TC1(Z),S1=.0538
255:,S2=-.1961
260A:TC2(Z),S2=.1961
265:,S3=-.0228
270A:TC3(Z),S3=.0228
275:,S4=-.7692
280A:TC4(Z),S4=.7692
285:,S5=-.5882
290A:TC5(Z),S5=.5882
295:,S6=-.1961
300A:TC6(Z),S6=.1961
305:,S7=-.7692
310A:TC7(Z),S7=.7692
315:,S8=-.0568
320A:TC8(Z),S8=.0568
325:,S9=-.0625
330A:TC9(Z),S9=.0625
335:,S10=-.3333
340A:TC10(Z),S10=.3333
345:,S11=-.3333
350A:TC11(Z),S11=.3333
355:,S12=-.1961
360A:TC12(Z),S12=.1961
365:,S13=-.3030
370A:TC13(Z),S13=.3030
375:,S14=-.1961
380A:TC14(Z),S14=.1961
385:,S15=-.08
390A:TC15(Z),S15=.08
395:,S16=-.0526
400A:TC16(Z),S16=.0526
405:,S17=-.3030
410A:TC17(Z),S17=.3030
415:,S18=-.1818
420A:TC18(Z),S18=.1818
425:,S19=-.7692
430A:TC19(Z),S19=.7692
435:,S20=-.2222
440A:TC20(Z),S20=.2222
445:,S21=-.0740
450A:TC21(Z),S21=.0740
455:,S22=-.0568
460A:TC22(Z),S22=.0568
465:,S23=-.1136
470A:TC23(Z),S23=.1136
475:,S24=-.1961
480A:TC24(Z),S24=.1961
485:,S25=-.1961
490A:TC25(Z),S25=.1961
```

```
495:,S26=-.0286
500A:TC26(Z),S26=.0286
505:,S27=-.0048
510A:TC27(Z),S27=.0048
515:,S28=-.0571
520****                                   ****
525****   OBJECTIVE FUNCTION            ****
530****                                  ****
535MATRIX:TIME(FREE),S1=-.00700
540:,S2=-.00700
545:,S3=-.00082
550:,S4=-.02747
555:,S5=-.02101
560:,S6=-.00700
565:,S7=-.02747
570:,S8=-.00203
575:,S9=-.00223
580:,S10=-.01190
585:,S11=-.01190
590:,S12=-.00700
595:,S13=-.01082
600:,S14=-.00700
605:,S15=-.00286
610:,S16=-.00188
615:,S17=-.01082
620:,S18=-.00649
625:,S19=-.02747
630:,S20=-.00794
635:,S21=-.00265
640:,S22=-.00203
645:,S23=-.00406
650:,S24=-.00700
655:,S25=-.00700
660:,S26=-.00102
665:,S27=-.00017
670:,S28=-.00204
```

```
675****                         ****
680**** RIGHT HAND SIDE VALUES ****
685****                           ****
690**** FUEL QUANTITY CONSTRAINT ****
695RHS:FUEL,RHSV=101976
700**** TIME EQUALITY CONSTRAINTS ****
705:TC1=-4.775
710:TC2=-21.665
715:TC3=164.94
720:TC4=-104.07
725:TC5=107.87
730:TC6=34.66
735:TC7=-[illegible]27.4088
740:TC8=12.2738
745:TC9=1.0417
750:TC10=0
755:TC11=179.4333
760:TC12=-44.6
765:TC13=-102.475
770:TC14=110.975
775:TC15=103.1575
780:TC16=-172.2575
785:TC17=-45.4455
790:TC18=146.8455
795:TC19=-136.7444
800:TC20=-37.0371
805:TC21=123.5267
810:TC22=-119.3179
815:TC23=26.2977
820:TC24=0
825:TC25=-14.7393
830:TC26=85.7143
835:TC27=-120
840END***
845$:DATA:I*
850:PREPRO
855:TITLE:GENERATOR FUEL ALLOCATION PLAN
860:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
865:SETUP:SOURCE=GFP
870:SET:OBJ=TIME,RHS=RHSV
875:PICTURE
880:PRIMAL
885:OUTPUT
890:ENDLP
895$:ENDJOB
900***EOF
```

APPENDIX C

ROBINS AFB OPTIMAL OUTPUT

F11#T 01 04/16/80 GENERATOR FUEL ALLOCATION PLAN VERB= PRIMAL PAGE 17

PRNAM=GFP : : FUNCT= 3.71729123+ OBJ=TIME : : RHS=RHSV : :

ITEM	ETA	NUM	FUNCTIONAL	NIMES	NDJS	VALUE2	INCOMING	VECTOR NAME	IN	KJ	OUT	KJ	CCT	VPC	ACT	NCT	FCT	A.TIM
1	1	1	3.71729123+	24	5	2939.13029-	S5	:	: P	34S	Z	5L	1	8	1A	1	6	.114
2	2	2	4.49547184+	23		1995.80099-	S3	:	: P	32S	Z	3L	2		1A	1	6	. 21
3	3	3	4.93512070+	22		1971.25318-	S8	:	: P	37S	Z	9L	3		1A	1	6	. 17
4	4	4	5.27731891+	21		1961.70339-	S2	:	: P	31S	Z	2L	4		1A	1	6	. 17
5	5	5	8.93526602+	20	5	1756.75338-	S14	:	: P	43S	Z	14L	1	7	1A	1	11	. 38
6	6	6	9.51721403+	19		1739.75338-	S13	:	: P	42S	Z	15L	2		1A	1	11	. 19
7	7	7	13.4185328+	18		1667.55339-	S15	:	: P	44S	Z	13L	3		1A	1	11	. 17
8	8	8	13.1149304+	17		1665.46990-	S9	:	: P	38S	Z	18L	4		1A	1	11	. 28
9	9	9	13.4849134+	17		1665.46998-	S11	:	: P	40S	Z	11L	5		1A	1	11	. 12
10	10	10	17.7721457+	16	5	1545.46998-	S28	:	: P	57S	Z	28L	1	13	1A	1	16	. 38
11	11	11	19.3944852+	15		1454.57899-	S18	:	: P	47S	Z	18L	2		1A	1	16	. 17
12	12	12	20.7208137+	14		1380.50479-	S21	:	: P	50S	Z	21L	3		1A	1	16	. 15
13	13	13	21.6608738+	13		1327.90939-	S23	:	: P	52S	Z	24L	4		1A	1	16	. 15
14	14	14	22.1763460+	12		1299.43878-	S26	:	: P	55S	Z	26L	5		1A	1	16	. 12
15	15	15	17.8141904+	11	6	939.564193-	S10	:	: P	39S	Z	12L	1	28	2A	2	21	. 43
16	16	16	55.8549760+	10		734.764199-	S17	:	: P	46S	Z	19L	2		2A	2	21	. 17
17	17	17	51.2428212+	9		563.784988-	S20	:	: P	49S	Z	22L	3		2A	2	21	. 15
18	18	18	71.1444292+	8		494.465084-	S12	:	: P	41S	Z	8L	4		2A	2	21	. 15
19	19	19	99.0699219+	7	6	355.965004-	S1	:	: P	30S	Z	4L	1	28	3A	2	26	. 43
20	20	20	100.129098+	6		352.165004-	S4	:	: P	33S	Z	6L	2		3A	2	26	. 16
21	21	21	110.934577+	5	5	317.505005-	S6	:	: P	35S	Z	7L	1	28	4A	1	31	. 52
22	22	22	131.254432+	4		285.107498-	S7	:	: P	36S	Z	16L	2		4A	1	31	. 19
23	23	23	131.254432+	4	3	285.107498-	S24	:	: P	53S	Z	25L	1	28	5A		34	. 19
24	24	24	111.389372+	3		143.157497-	S25	:	: P	54S	Z	27L	2		5A		34	. 13
25	25	25	146.195709+	2	1	121.112299-	S27	:	: P	56S	Z	23L	1	28	6A		35	. 33
26	26	26	162.248714+	1	1	78.8575881-	S22	:	: P	51S	Z	20L	1	28	7A		36	. 33
27	27	27	192.600832+		1	.769200027-	S19	:	: P	48S	Z	17L	1	28	8A		37	. 33
28	28	28	232.602773+		1	.057564184-	S16	:	: P	45S	P	1L	1	28	9A		38	. 38
14 DINV		INVEPT									DOINV		DEMAND 36527				32956	11
15 CURNT		CURRENT															32962	12
45		PRIMAL															32962	13

OPTIMAL SOLUTION

Robins AFB Iterations

F118T 01 04/16/86 GENERATOR FUEL ALLOCATION PLAN VERB= OUTPUT PAGE 19

PRNAM=GFP : : FUNCT= 232.602773. OBJ=TIME : : RHS=RHSV : :

ROWS

SLACK VALUES

ROW KJ	TYPE	ROW NAME	LOGICAL INDIC.	L-VALUE	PI	RHS
1	PLUS	FUEL		.	.00224673.	101976.00000000.
2	ZERO	TC1		.	.00835069.	4.77500003-
3	ZERO	TC2		.	.11250968.	21.66500020-
4	ZERO	TC3		.	.05001367.	164.93999862.
5	ZERO	TC4		.	.08200523.	104.07000065-
6	ZERO	TC5		.	.11470470.	107.86999980.
7	ZERO	TC6		.	.13894378.	34.65999984.
8	ZERO	TC7		.	.17173526.	227.40880012-
9	ZERO	TC8		.	.16791954.	12.27379989.
10	ZERO	TC9		.	.16765181.	1.04169999.
11	ZERO	TC10		.	.19661451.	.
12	ZERO	TC11		.	.22557721.	179.43329811.
13	ZERO	TC12		.	.24981621.	44.60000038-
14	ZERO	TC13		.	.27811082.	102.47500038-
15	ZERO	TC14		.	.30234982.	110.97499943.
16	ZERO	TC15		.	.31001566.	103.15749931.
17	ZERO	TC16		.	.30384355.	172.25750160-
18	ZERO	TC17		.	.33133817.	45.44550037-
19	ZERO	TC18		.	.35467847.	146.84549904.
20	ZERO	TC19		.	.38747084.	136.74440002-
21	ZERO	TC20		.	.41309230.	37.03710031-
22	ZERO	TC21		.	.41854186.	123.52669906.
23	ZERO	TC22		.	.41472614.	119.31790066-
24	ZERO	TC23		.	.43068801.	26.29769993.
25	ZERO	TC24		.	.45492781.	.
26	ZERO	TC25		.	.47916601.	14.73930001-
27	ZERO	TC26		.	.43627325.	85.71429920.
28	ZERO	TC27		.	.00362054.	120.00000000-
29	FREE	TIME	*BASIS	232.60277394.	1.00000000.	.

Robins AFB Slack Values

F110T 01 04/16/80 GENERATOR FUEL ALLOCATION PLAN VERA= OUTPUT PAGE 28

PRNAM=GFP : : FUNCT= 232.602773. OBJ=TIME : : RHS=RHSV : :

COLUMNS

FUEL ALLOCATIONS

Generator #

COL KJ	TYPE	COLUMN NAME	STRUCT. INDIC.	X-VALUE	DJ		COST*SCALE
30	PLUS	S1	*BASIS	4570.82483105.	.	-	.00700000-
31	PLUS	S2	*BASIS	1278.35534224.	.	-	.00700000-
32	PLUS	S3	*BASIS	11945.19644718.	.	-	.00082000-
33	PLUS	S4	*BASIS	139.63920794.	.	-	.02747000-
34	PLUS	S5	*BASIS	359.53839483.	.	.	.02101000-
35	PLUS	S6	*BASIS	528.35538998.	.	-	.00700000-
36	PLUS	S7	*BASIS	89.63920332.	.	-	.02747000-
37	PLUS	S8	*BASIS	5217.59283697.	.	.	.00203000-
38	PLUS	S9	*BASIS	4545.34756388.	.	.	.00223000-
39	PLUS	S10	*BASIS	849.21623499.	.	-	.01190000-
40	PLUS	S11	*BASIS	849.21622558.	.	-	.01190000-
41	PLUS	S12	*BASIS	528.35526853.	.	-	.00700000-
42	PLUS	S13	*BASIS	489.14345279.	.	-	.01982000-
43	PLUS	S14	*BASIS	1278.35525699.	.	-	.00700000-
44	PLUS	S15	*BASIS	1746.38008414.	.	-	.00286000-
45	PLUS	S16	*BASIS	694.92326016.	.	.	.00188000-
46	PLUS	S17	*BASIS	659.14344113.	.	-	.01982000-
47	PLUS	S18	*BASIS	1398.54764626.	.	-	.00649000-
48	PLUS	S19	*BASIS	139.63919398.	.	.	.02747000-
49	PLUS	S20	*BASIS	1098.88674718.	.	.	.00794000-
50	PLUS	S21	*BASIS	3799.80132609.	.	-	.00265000-
51	PLUS	S22	*BASIS	2775.79673564.	.	-	.00203000-
52	PLUS	S23	*BASIS	2438.23198216.	.	-	.00486000-
53	PLUS	S24	*BASIS	1278.35518818.	.	-	.00700000-
54	PLUS	S25	*BASIS	1278.35517684.	.	-	.00700000-
55	PLUS	S26	*BASIS	9280.58557087.	.	.	.00102000-
56	PLUS	S27	*BASIS	37439.67597289.	.	-	.00017000-
57	PLUS	S28	*BASIS	5248.86948862.	.	.	.00204000-
58	RHS	RHSV		. .	232.60277394.		. .

Robins AFB Fuel Allocations

APPENDIX D

HILL AFB INPUT PROGRAMS

Hill AFB Original Input Program

```
10##S,R(J) :,8,16;;.16
15$:IDENT:UP1186, MOTT/NELSON THESIS
20$:USERID:80A053$KR79
25$:PROGRAM:RLHS
30$:LIMITS:10,39K,,5K
35$:PRMFL:H*,R,R,AF.LIB/LP.PAC
40$:REMOTE:SO,SL
45$:DISC:AA,A1,10R
50$:DISC:AB,A2,10R
55$:DISC:AC,A3,10R
60$:DISC:AD,A4,10R
65$:DISC:AE,A5,10R
70$:DATA:IN
75FILE:ELEC
80**** HILL AFB FUEL PLAN ****
85****                        ****
90**** CONSTRAINT MATRIX ****
95****                   ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S1(P)=1
110:,S2(P)=1
115:,S3(P)=1
120:,S4(P)=1
125:,S5(P)=1
130:,S6(P)=1
135:,S7(P)=1
140:,S8(P)=1
145:,S9(P)=1
150:,S10(P)=1
155:,S11(P)=1
160:,S12(P)=1
165:,S13(P)=1
170:,S14(P)=1
```

```
175:,S15(P)=1
180:,S16(P)=1
185:,S17(P)=1
190:,S18(P)=1
195:,S19(P)=1
200:,S20(P)=1
205:,S21(P)=1
210:,S22(P)=1
215:,S23(P)=1
220:,S24(P)=1
225:,S25(P)=1
230:,S26(P)=1
235:,S27(P)=1
240:,S28(P)=1
245:,S29(P)=1
250:,S30(P)=1
255:,S31(P)=1
260:,S32(P)=1
265:,S33(P)=1
270:,S34(P)=1
275:,S35(P)=1
280:,S36(P)=1
285:,S37(P)=1
290:,S38(P)=1
295:,S39(P)=1
300:,S40(P)=1
305:,S41(P)=1
310:,S42(P)=1
315:,S43(P)=1
320:,S44(P)=1
325:,S45(P)=1
330:,S46(P)=1
335:,S47(P)=1
340**** TIME EQUALITY CONSTRAINTS ****
345MATRIX:TC1(Z),S1=.0357
350:,S2=-.1136
355A:TC2(Z),S2=.1136
360:,S3=-.08
365A:TC3(Z),S3=.08
370:,S4=-.303
375A:TC4(Z),S4=.303
380:,S5=-.303
385A:TC5(Z),S5=.303
390:,S6=-.1961
395A:TC6(Z),S6=.1961
400:,S7=-.303
405A:TC7(Z),S7=.303
410:,S8=-.25
415A:TC8(Z),S8=.25
420:,S9=-.25
425A:TC9(Z),S9=.25
```

```
430:,S10=-.1136
435A:TC10(Z),S10=.1136
440:,S11=-.1961
445A:TC11(Z),S11=.1961
450:,S12=-.0408
455A:TC12(Z),S12=.0408
460:,S13=-.1538
465A:TC13(Z),S13=.1538
470:,S14=-.303
475A:TC14(Z),S14=.303
480:,S15=-.1538
485A:TC15(Z),S15=.303
490:,S16=-.303
495A:TC16(Z),S16=.303
500:,S17=-.0741
505A:TC17(Z),S17=.0741
510:,S18=-.4
515A:TC18(Z),S18=.4
520:,S19=-.0317
525A:TC19(Z),S19=.0317
530:,S20=-.1136
535A:TC20(Z),S20=.1136
540:,S21=-.0741
545A:TC21(Z),S21=.0741
550:,S22=-.1
555A:TC22(Z),S22=.1
560:,S23=-.0435
565A:TC23(Z),S23=.0435
570:,S24=-.0286
575A:TC24(Z),S24=.0286
580:,S25=-.0345
585A:TC25(Z),S25=.0345
590:,S26=-.1136
595A:TC26(Z),S26=.1136
600:,S27=-.303
605A:TC27(Z),S27=.303
610:,S28=-.1538
615A:TC28(Z),S28=.1538
620:,S29=-.1136
625A:TC29(Z),S29=.1136
630:,S30=-.1111
635A:TC30(Z),S30=.1111
640:,S31=-.1538
645A:TC31(Z),S31=.1538
650:,S32=-.1961
655A:TC32(Z),S32=.1961
660:,S33=-.0741
665A:TC33(Z),S33=.0741
670:,S34=-.1136
675A:TC34(Z),S34=.1136
680:,S35=-.0741
```

```
685A:TC35(Z),S35=.0741
690:,S36=-.3030
695A:TC36(Z),S36=.3030
700:,S37=-.3030
705A:TC37(Z),S37=.3030
710:,S38=-.4
715A:TC38(Z),S38=.4000
720:,S39=-.4
725A:TC39(Z),S39=.4000
730:,S40=-.1136
735A:TC40(Z),S40=.1136
740:,S41=-.0741
745A:TC41(Z),S41=.0741
750:,S42=-.0313
755A:TC42(Z),S42=.0313
760:,S43=-.0357
765A:TC43(Z),S43=.0357
770:,S44=-.0125
775A:TC44(Z),S44=.0125
780:,S45=-.0357
785A:TC45(Z),S45=.0357
790:,S46=-.0156
795A:TC46(Z),S46=.0156
800:,S47=-.05714
805****                                           ******
810****   OBJECTIVE FUNCTION                      *******
815****                                           ******
820MATRIX:TIME(FREE),S1=-.00076
825:,S2=-.00242
830:,S3=-.00170
835:,S4=-.00645
840:,S5=-.00645
845:,S6=-.00417
850:,S7=-.00645
855:,S8=-.00532
860:,S9=-.00532
865:,S10=-.00242
870:,S11=-.00417
875:,S12=-.00087
880:,S13=-.00327
885:,S14=-.00645
890:,S15=-.00327
895:,S16=-.00645
900:,S17=-.00158
905:,S18=-.00851
910:,S19=-.00068
915:,S20=-.00242
920:,S21=-.00158
925:,S22=-.00213
930:,S23=-.00093
935:,S24=-.00061
```

```
940:,S25=-.00073
945:,S26=-.00242
950:,S27=-.00645
955:,S28=-.00327
960:,S29=-.00242
965:,S30=-.00236
970:,S31=-.00327
975:,S32=-.00417
980:,S33=-.00158
985:,S34=-.00242
990:,S35=-.00158
995:,S36=-.00645
1000:,S37=-.00645
1005:,S38=-.00851
1010:,S39=-.00851
1015:,S40=-.00242
1020:,S41=-.00158
1025:,S42=-.00066
1030:,S43=-.00076
1035:,S44=-.00027
1040:,S45=-.00076
1045:,S46=-.00033
1050:,S47=-.00122
1055****                         ****
1060**** RIGHT HAND SIDE VALUES ****
1065****                         ****
1070**** FUEL QUANTITY CONSTRAINT ****
1075RHS:FUEL,RHSV=215712
1080**** TIME EQUALITY CONSTRAINTS ****
1085:TC1=81.1688
1090:TC2=-10.4545
1095:TC3=-8.4848
1100:TC4=136.3636
1105:TC5=-111.4082
1110:TC6=-24.9554
1115:TC7=98.4848
1120:TC8=0
1125:TC9=147.7273
1130:TC10=103.6097
1135:TC11=-193.6375
1140:TC12=141.6013
1145:TC13=-78.0886
1150:TC14=-64.9884
1155:TC15=140.746
1160:TC16=-58.1818
1165:TC17=-82.7334
1170:TC18=560.8286
1175:TC19=-332.7922
1180:TC20=-246.6364
1185:TC21=42
1190:TC22=36.9565
```

```
1195:TC23=427.3292
1200:TC24=-445.3202
1205:TC25=44.6709
1210:TC26=37.8788
1215:TC27=10.0233
1220:TC28=77.0979
1225:TC29=-183.0808
1230:TC30=105.9829
1235:TC31=-153.1071
1240:TC32=-.3944
1245:TC33=.088
1250:TC34=-.088
1255:TC35=-.2289
1260:TC36=0
1265:TC37=.367
1270:TC38=0
1275:TC39=-.275
1280:TC40=-.088
1285:TC41=111.963
1290:TC42=0
1295:TC43=0
1300:TC44=0
1305:TC45=0
1310:TC46=-120
1315END***
1320$:DATA:I*
1325:PREPRO
1330:TITLE:GENERATOR FUEL ALLOCATION PLAN
1335:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
1340:SETUP:SOURCE=GFP
1345:SET:OBJ=TIME,RHS=RHSV
1350:PICTURE
1355:PRIMAL
1360:OUTPUT
1365:ENDLP
1370$:ENDJOB
1375***EOF
```

AD-A087 088 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL--ETC F/G 15/5
A STUDY OF FUEL SUPPLIES FOR EMERGENCY POWER GENERATION AT AIR --ETC(U)
JUN 80 S J MOTT, S D NELSON

UNCLASSIFIED AFIT-LSSR-17-80 NL

2 of 2
AD
A087088

END
DATE
FILMED
9-80
DTIC

Hill AFB Adjusted Input Program

```
10##S,R(SL) :,8,16;;,16
15$:IDENT:WP1186, MOTT/NELSON THESIS
20$:USERID:80A053$KR79
25$:PROGRAM:RLHS
30$:LIMITS:10,39K,,5K
35$:PRMFL:H*,R,R,AF.LIB/LP.PAC
40$:REMOTE:SO,SL
45$:DISC:AA,A1,10R
50$:DISC:AB,A2,10R
55$:DISC:AC,A3,10R
60$:DISC:AD,A4,10R
65$:DISC:AE,A5,10R
70$:DATA:IN
75FILE:ELEC
80**** HILL AFB FUEL PLAN ****
85****                   ****
90**** CONSTRAINT MATRIX ****
95****                   ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S1(P)=1
110:,S2(P)=1
115:,S3(P)=1
```

```
120:,S4(P)=1
125:,S5(P)=1
130:,S6(P)=1
135:,S7(P)=1
140:,S8(P)=1
145:,S9(P)=1
150:,S10(P)=1
155:,S11(P)=1
160:,S12(P)=1
165:,S13(P)=1
170:,S14(P)=1
175:,S15(P)=1
180:,S16(P)=1
185:,S17(P)=1
190:,S18(P)=1
195:,S20(P)=1
200:,S21(P)=1
205:,S22(P)=1
210:,S23(P)=1
215:,S25(P)=1
220:,S26(P)=1
225:,S27(P)=1
230:,S28(P)=1
235:,S29(P)=1
240:,S30(P)=1
245:,S31(P)=1
250:,S32(P)=1
255:,S33(P)=1
260:,S34(P)=1
265:,S35(P)=1
270:,S36(P)=1
275:,S37(P)=1
280:,S38(P)=1
285:,S39(P)=1
290:,S40(P)=1
295:,S41(P)=1
300:,S42(P)=1
305:,S43(P)=1
310:,S44(P)=1
315:,S45(P)=1
320:,S46(P)=1
325:,S47(P)=1
330**** TIME EQUALITY CONSTRAINTS ****
335MATRIX:TC1(Z),S1=.0357
340:,S2=-.1136
345A:TC2(Z),S2=.1136
350:,S3=-.08
355A:TC3(Z),S3=.08
360:,S4=-.303
365A:TC4(Z),S4=.303
370:,S5=-.303
```

```
375A:TC5(Z),S5=.303
380:,S6=-.1961
385A:TC6(Z),S6=.1961
390:,S7=-.303
395A:TC7(Z),S7=.303
400:,S8=-.25
405A:TC8(Z),S8=.25
410:,S9=-.25
415A:TC9(Z),S9=.25
420:,S10=-.1136
425A:TC10(Z),S10=.1136
430:,S11=-.1961
435A:TC11(Z),S11=.1961
440:,S12=-.0408
445A:TC12(Z),S12=.0408
450:,S13=-.1538
455A:TC13(Z),S13=.1538
460:,S14=-.303
465A:TC14(Z),S14=.303
470:,S15=-.1538
475A:TC15(Z),S15=.303
480:,S16=-.303
485A:TC16(Z),S16=.303
490:,S17=-.0741
495A:TC17(Z),S17=.0741
500:,S18=-.4
505A:TC18(Z),S18=.4
510:,S20=-.1136
515A:TC20(Z),S20=.1136
520:,S21=-.0741
525A:TC21(Z),S21=.0741
530:,S22=-.1
535A:TC22(Z),S22=.1
540:,S23=-.0435
545A:TC23(Z),S23=.0435
550:,S25=-.0345
555A:TC25(Z),S25=.0345
560:,S26=-.1136
565A:TC26(Z),S26=.1136
570:,S27=-.303
575A:TC27(Z),S27=.303
580:,S28=-.1538
585A:TC28(Z),S28=.1538
590:,S29=-.1136
595A:TC29(Z),S29=.1136
600:,S30=-.1111
605A:TC30(Z),S30=.1111
610:,S31=-.1538
615A:TC31(Z),S31=.1538
620:,S32=-.1961
625A:TC32(Z),S32=.1961
```

```
630:,S33=-.0741
635A:TC33(Z),S33=.0741
640:,S34=-.1136
645A:TC34(Z),S34=.1136
650:,S35=-.0741
655A:TC35(Z),S35=.0741
660:,S36=-.3030
665A:TC36(Z),S36=.3030
670:,S37=-.3030
675A:TC37(Z),S37=.3030
680:,S38=-.4
685A:TC38(Z),S38=.4000
690:,S39=-.4
695A:TC39(Z),S39=.4000
700:,S40=-.1136
705A:TC40(Z),S40=.1136
710:,S41=-.0741
715A:TC41(Z),S41=.0741
720:,S42=-.0313
725A:TC42(Z),S42=.0313
730:,S43=-.0357
735A:TC43(Z),S43=.0357
740:,S44=-.0125
745A:TC44(Z),S44=.0125
750:,S45=-.0357
755A:TC45(Z),S45=.0357
760:,S46=-.0156
765A:TC46(Z),S46=.0156
770:,S47=-.05714
775****                                                   ******
780****   OBJECTIVE FUNCTION                              *******
785****                                                   ******
790MATRIX:TIME(FREE),S1=-.00076
795:,S2=-.00242
800:,S3=-.00170
805:,S4=-.00645
810:,S5=-.00645
815:,S6=-.00417
820:,S7=-.00645
825:,S8=-.00532
830:,S9=-.00532
835:,S10=-.00242
840:,S11=-.00417
845:,S12=-.00087
850:,S13=-.00327
855:,S14=-.00645
860:,S15=-.00327
865:,S16=-.00645
870:,S17=-.00158
875:,S18=-.00851
880:,S20=-.00242
```

```
885:,S21=-.00158
890:,S22=-.00213
895:,S23=-.00093
900:,S25=-.00073
905:,S26=-.00242
910:,S27=-.00645
915:,S28=-.00327
920:,S29=-.00242
925:,S30=-.00236
930:,S31=-.00327
935:,S32=-.00417
940:,S33=-.00158
945:,S34=-.00242
950:,S35=-.00158
955:,S36=-.00645
960:,S37=-.00645
965:,S38=-.00851
970:,S39=-.00851
975:,S40=-.00242
980:,S41=-.00158
985:,S42=-.00066
990:,S43=-.00076
995:,S44=-.00027
1000:,S45=-.00076
1005:,S46=-.00033
1010:,S47=-.00122
1015****                         ****
1020**** RIGHT HAND SIDE VALUES ****
1025****                         ****
1030**** FUEL QUANTITY CONSTRAINT ****
1035RHS:FUEL,RHSV=215712
1040**** TIME EQUALITY CONSTRAINTS ****
1045:TC1=81.1688
1050:TC2=-10.4545
1055:TC3=-8.4848
1060:TC4=136.3636
1065:TC5=-111.4082
1070:TC6=-24.9554
1075:TC7=98.4848
1080:TC8=0
1085:TC9=147.7273
1090:TC10=103.6097
1095:TC11=-193.6375
1100:TC12=141.6013
1105:TC13=-78.0886
1110:TC14=-64.9884
1115:TC15=140.746
1120:TC16=-58.1818
1125:TC17=-82.7334
1130:TC18=228.0364
1135:TC20=-246.6364
```

```
1140:TC21=42
1145:TC22=36.9565
1150:TC23=-17.991
1155:TC25=44.6709
1160:TC26=37.8788
1165:TC27=10.0233
1170:TC28=77.0979
1175:TC29=-183.0808
1180:TC30=105.9829
1185:TC31=-153.1071
1190:TC32=-.3944
1195:TC33=.088
1200:TC34=-.088
1205:TC35=-.2289
1210:TC36=0
1215:TC37=.367
1220:TC38=0
1225:TC39=-.275
1230:TC40=-.088
1235:TC41=111.963
1240:TC42=0
1245:TC43=0
1250:TC44=0
1255:TC45=0
1260:TC46=-120
1265END***
1270$:DATA:I*
1275:PREPRO
1280:TITLE:GENERATOR FUEL ALLOCATION PLAN
1285:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
1290:SETUP:SOURCE=GFP
1295:SET:OBJ=TIME,RHS=RHSV
1300:PICTURE
1305:PRIMAL
1310:OUTPUT
1315:ENDLP
1320$:ENDJOB
1325***EOF
```

APPENDIX E

HILL AFB SUBOPTIMAL OUTPUT

C244T 01 04/14/80 GENERATOR FUEL ALLOCATION PLAN VERB= PRIMAL PAGE 17

PRMAN=GFP : : FUNCT= 1.72796324+ OBJ=TIME : : RHS=RHSV : :

ITER	ETA	NUR	FUNCTIONAL	NINFS	NBJS	VALUE?	INCOMING	VECTOR	NAME	IN	KJ	OUT	KJ	CCT	VPC	.CT	NCT	FCT	A.TIM
1	1	1	1.72796324+	38	5	4338.66235-	S1	:	:	P	49S	Z	2L	1	10	1A	1	6	.148
2	2	2	2.25912785+	37		4288.75158-	S7	:	:	P	55S	Z	7L	2		1A	1	6	.34
3	3	3	2.43089988+	36		4271.78198-	S4	:	:	P	52S	Z	4L	3		1A	1	6	.19
4	4	4	2.43089988+	36		4271.73198-	S9	:	:	P	57S	Z	9L	4		1A	1	6	.19
5	5	5	5.45924560+	35	5	3988.57937-	S12	:	:	P	68S	Z	13L	1	11	1A	1	11	.44
6	6	6	6.84899155+	34		3795.55792-	S15	:	:	P	63S	Z	15L	2		1A	1	11	.24
7	7	7	8.60114467+	33		3630.89112-	S18	:	:	P	66S	Z	18L	3		1A	1	11	.28
8	8	8	11.0795459+	32		3513.72751-	S17	:	:	P	65S	Z	17L	4		1A	1	11	.18
9	9	9	11.9750925+	31		3429.77751-	S21	:	:	P	69S	Z	22L	5		1A	1	11	.15
10	10	10	14.2263945+	30	5	3217.76172-	S30	:	:	P	78S	Z	31L	1	9	1A	1	16	.41
11	11	11	15.1716448+	29		3128.41997-	S25	:	:	P	73S	Z	26L	2		1A	1	16	.28
12	12	12	16.7880233+	28		3052.66232-	S26	:	:	P	74S	Z	27L	3		1A	1	16	.28
13	13	13	18.3552831+	27		2978.74933-	S22	:	:	P	78S	Z	23L	4		1A	1	16	.18
14	14	14	18.9941923+	26		2958.78273-	S27	:	:	P	75S	Z	28L	5		1A	1	16	.25
15	15	15	18.9960587+	25	5	2958.52678-	S33	:	:	P	81S	Z	34L	1	7	1A	1	21	.48
16	16	16	21.5581867+	24	5	2838.52678-	S47	:	:	P	95S	Z	47L	1	10	1A	1	26	.49
17	17	17	21.5488631+	23		2838.35871-	S41	:	:	P	89S	Z	41L	2		1A	1	26	.18
18	18	18	32.2918963+	22	6	2582.99893-	S23	:	:	P	71S	Z	21L	1	23	2A	2	31	.54
19	19	19	35.4286938+	21		2355.93213-	S6	:	:	P	54S	Z	8L	2		2A	2	31	.28
20	20	20	35.9553984+	20		2335.87313-	S3	:	:	P	51S	Z	3L	3		2A	2	31	.19
21	21	21	36.1199422+	19		2315.85721-	S14	:	:	P	62S	Z	16L	4		2A	2	31	.17
22	22	22	42.6941123+	18	6	2141.66148-	S28	:	:	P	76S	Z	29L	1	17	2A	2	36	.51
23	23	23	42.7858344+	17		2161.11142-	S40	:	:	P	88S	Z	40L	2		2A	2	36	.21
24	24	24	52.7819844+	16	6	2043.68712-	S2	:	:	P	58S	Z	5L	1	15	3A	2	41	.52
25	25	25	55.9259166+	15		1967.92952-	S8	:	:	P	56S	Z	6L	2		3A	2	41	.19
26	26	26	78.0752134+	14	7	1448.63898-	S20	:	:	P	68S	Z	24L	1	20	3A	3	46	.56
27	27	27	98.1391438+	13		1235.86657-	S16	:	:	P	64S	Z	14L	2		3A	3	46	.27
28	28	28	98.1391438+	13		1235.86657-	S36	:	:	P	84S	Z	37L	3		3A	3	46	.17
29	29	29	111.178159+	12	7	1126.01986-	S5	:	:	P	53S	Z	18L	1	16	4A	3	51	.54
30	30	30	111.187985+	11		1125.56827-	S37	:	:	P	85S	Z	36L	2		4A	3	51	.19
31	31	31	122.167127+	10	10	971.880834-	S13	:	:	P	61S	Z	12L	1	47	5A	2	56	.62
32	32	32	144.218481+	9		867.398338-	S10	:	:	P	58S	Z	11L	2		5A	2	56	.28
33	33	33	144.224824+	8		867.222336-	S35	:	:	P	83S	Z	35L	3		5A	2	56	.17
34	34	34	144.224824+	8		867.222336-	S39	:	:	P	87S	Z	39L	4		5A	2	56	.14
35	35	35	184.446989+	7	8	698.953682-	S11	:	:	P	59S	Z	19L	1	47	6A	1	61	.64
36	36	36	184.852326+	6		698.853485-	S34	:	:	P	82S	Z	38L	2		6A	1	61	.19
37	37	37	184.181459+	5	7	698.344981-	S38	:	:	P	86S	Z	33L	1	47	7A	2	66	.61
38	38	38	207.813455+	4	7	467.653473-	S32	:	:	P	88S	Z	42L	1	47	8A	2	71	.64
39	39	39	207.813455+	4	6	467.653473-	S42	:	:	P	90S	Z	43L	1	47	9A	2	76	.44
40	40	40	207.813455+	4	5	467.653473-	S43	:	:	P	91S	Z	44L	1	47	10A	1	81	.78
41	41	41	207.813455+	4	4	467.653473-	S44	:	:	P	92S	Z	45L	1	47	11A		85	.63
42	42	42	207.813455+	4	1	467.653473-	S45	:	:	P	93S	Z	46L	1	94	13A		89	.94
43	43	43	222.843518+	3	1	425.898083-	S46	:	:	P	94S	Z	32L	1	47	14B		90	.46
44	44	44	251.598034+	2	1	348.792183-	S31	:	:	P	79S	Z	30L	1	47	15B		91	.49
45	45	45	358.984455+	2	1	145.758882-	S29	:	:	P	77S	P	1L	1	47	16B		92	.53
14 BINV		INVERT										BOINV		DEMAND 36527				44678	14
15 CURNT		CURRENT																44444.	16

Hill AFB Iterations, N=47--Suboptimal Solution

C244T 01 04/14/80 GENERATOR FUEL ALLOCATION PLAN VERB= OUTPUT PAGE 28

PRNAM=GFP : : FUNCT= 350.984455+ OBJ=TIME : : RHS=RHSV : :

ROWS

SLACK VALUES

ROW KJ	TYPE	ROW NAME	LOGICAL INDIC.	L-VALUE	PI	RHS
1	PLUS	FUEL		. .	.00252358+	215712.00000000+
2	ZERO	TC1		. .	.07060850-	81.16879940+
3	ZERO	TC2		. .	.09294312-	10.45450000-
4	ZERO	TC3		. .	.12444786-	8.48490010-
5	ZERO	TC4		. .	.13277651-	136.36359977+
6	ZERO	TC5		. .	.14118516-	111.40920026-
7	ZERO	TC6		. .	.15397480-	24.95540873-
8	ZERO	TC7		. .	.16230265-	98.40479930+
9	ZERO	TC8		. .	.17239697-	. .
10	ZERO	TC9		. .	.18249179-	147.72729873+
11	ZERO	TC10		. .	.20470590-	103.60960925+
12	ZERO	TC11		. .	.21757474-	193.63750076-
13	ZERO	TC12		. .	.27942719-	141.60179978+
14	ZERO	TC13		. .	.29583538-	78.06060016-
15	ZERO	TC14		. .	.30416483-	64.98940046-
16	ZERO	TC15		. .	.16271958-	140.74590830+
17	ZERO	TC16		. .	.17104415-	58.10180036-
18	ZERO	TC17		. .	.20510455-	82.73340034-
19	ZERO	TC18		. .	.21141351-	560.92859807+
20	ZERO	TC19	*BASIS (	73.14280032-)	1.00000000+	332.79228199-
21	ZERO	TC20		. .	.97778540+	246.63640872-
22	ZERO	TC21		. .	.94377900+	47.00000000+
23	ZERO	TC22		. .	.91849321+	36.95649957+
24	ZERO	TC23		. .	.86047990+	427.32919693+
25	ZERO	TC24	*BASIS (	72.61599586-)	1.00000000+	445.32028187-
26	ZERO	TC25		. .	.92685277+	44.67089987+
27	ZERO	TC26		. .	.90463817+	37.87879991+
28	ZERO	TC27		. .	.89630953+	18.02379993+
29	ZERO	TC28		. .	.87990136+	77.09789943+
30	ZERO	TC29		. .	.85768475+	183.00000181-
31	ZERO	TC30		. .	.83497227+	185.90209966+
32	ZERO	TC31		. .	.81856489+	153.10718144-
33	ZERO	TC32		. .	.80569526+	.39440000-
34	ZERO	TC33		. .	.77163886+	.00000000+
35	ZERO	TC34		. .	.74942426+	.00000000-
36	ZERO	TC35		. .	.71536786+	.22890000-
37	ZERO	TC36		. .	.70703922+	. .
38	ZERO	TC37		. .	.69871059+	.36700000+
39	ZERO	TC38		. .	.69240164+	. .
40	ZERO	TC39		. .	.68689270+	.27500000-
41	ZERO	TC40		. .	.66387810+	.00900000-
42	ZERO	TC41		. .	.62982170+	111.96299934+
43	ZERO	TC42		. .	.54919616+	. .
44	ZERO	TC43		. .	.47850746+	. .
45	ZERO	TC44		. .	.27662120+	. .

Hill AFB Slack Values, N=47

C244T 81 04/14/80 GENERATOR FUEL ALLOCATION PLAN VERB= OUTPUT PAGE 21

PRNAM=GFP : : FUNCT= 358.984455+ OBJ=TIME : : RHS=RHSV : :

ROWS

SLACK VALUES

ROW KJ	TYPE	ROW NAME	LOGICAL INDIC.	L-VALUE		PI		RHS	
46	ZERO	TC45		.	+	.20593278+		.	+
47	ZERO	TC46		.	+	.04416485+		120.00000000-	
48	FREE	TIME	*BASIS	358.98445511+		.	+	.	+

Hill AFB Slack Values, N=47

C244T 01 04/14/80 GENERATOR FUEL ALLOCATION PLAN VERB= OUTPUT PAGE 22

PRHAM=GFP : : FUNCT= 350.984455+ OBJ=TIME : : RHS=RHSV : :

COLUMNS

Generator # FUEL ALLOCATIONS

COL KJ	TYPE	COLUMN NAME	STRUCT. INDIC.	X-VALUE	RJ		COST+SCALE
49	PLUS	S1	*BASIS	14040.20212872+	.	-	.00074000-
50	PLUS	S2	*BASIS	3700.30693954+	.	+	.00242000-
51	PLUS	S3	*BASIS	5385.11709123+	.	-	.00170000-
52	PLUS	S4	*BASIS	1449.81570393+	.	+	.00645000-
53	PLUS	S5	*BASIS	999.77000695+	.	+	.00645000-
54	PLUS	S6	*BASIS	2112.09522452+	.	+	.00417000-
55	PLUS	S7	*BASIS	1449.81566318+	.	+	.00645000-
56	PLUS	S8	*BASIS	1363.23738261+	.	-	.00532000-
57	PLUS	S9	*BASIS	1363.23738261+	.	-	.00532000-
58	PLUS	S10	*BASIS	1699.66589489+	.	+	.00242000-
59	PLUS	S11	*BASIS	456.25077588+	.	+	.00417000-
60	PLUS	S12	*BASIS	6930.96600086+	.	-	.00087000-
61	PLUS	S13	*BASIS	920.00154890+	.	+	.00327000-
62	PLUS	S14	*BASIS	724.74303524+	.	+	.00645000-
63	PLUS	S15	*BASIS	1050.34109982+	.	+	.00327000-
64	PLUS	S16	*BASIS	1385.05203634+	.	-	.00645000-
65	PLUS	S17	*BASIS	6452.02704254+	.	+	.00158000-
66	PLUS	S18	*BASIS	1402.07150028+	.	-	.00051000-
67	PLUS	S19		. +	.04092539+		.00068000-
68	PLUS	S20	*BASIS	2205.64535198+	.	-	.00242000-
69	PLUS	S21	*BASIS	6032.46567359+	.	-	.00158000-
70	PLUS	S22	*BASIS	4642.05702818+	.	-	.00213000-
71	PLUS	S23	*BASIS	9023.65977189+	.	-	.00093000-
72	PLUS	S24		. +	.00651385+		.00061000-
73	PLUS	S25	*BASIS	10003.02046613+	.	-	.00073000-
74	PLUS	S26	*BASIS	2007.61707553+	.	-	.00242000-
75	PLUS	S27	*BASIS	957.60559049+	.	-	.00645000-
76	PLUS	S28	*BASIS	1021.39917632+	.	-	.00327000-
77	PLUS	S29	*BASIS	1707.26409137+	.	-	.00242000-
78	PLUS	S30	*BASIS	3475.37435007+	.	-	.00236000-
79	PLUS	S31	*BASIS	1021.39913400+	.	-	.00327000-
80	PLUS	S32	*BASIS	2209.27224286+	.	-	.00417000-
81	PLUS	S33	*BASIS	5051.99296505+	.	-	.00158000-
82	PLUS	S34	*BASIS	3816.41439336+	.	-	.00242000-
83	PLUS	S35	*BASIS	5051.99284435+	.	-	.00158000-
84	PLUS	S36	*BASIS	1431.00635137+	.	-	.00645000-
85	PLUS	S37	*BASIS	1431.00633376+	.	-	.00645000-
86	PLUS	S38	*BASIS	1003.73630953+	.	-	.00051000-
87	PLUS	S39	*BASIS	1003.73637944+	.	-	.00051000-
88	PLUS	S40	*BASIS	3010.39398246+	.	-	.00242000-
89	PLUS	S41	*BASIS	5055.02755761+	.	-	.00158000-
90	PLUS	S42	*BASIS	10284.17053982+	.	-	.00066000-
91	PLUS	S43	*BASIS	9016.65368798+	.	-	.00076000-
92	PLUS	S44	*BASIS	25751.56248283+	.	-	.00027000-
93	PLUS	S45	*BASIS	9014.65340640+	.	+	.00076000-

Hill AFB Fuel Allocations, N=47

C244T 01 04/14/80 GENERATOR FUEL ALLOCATION PLAN VERB= OUTPUT PAGE 23

PRNAM=GFP : : FUNCT= 358.984455+ OBJ=TIME : : RHS=RHSV : :

COLUMNS

Generator # FUEL ALLOCATIONS

COL KJ	TYPE	COLUMN NAME	STRUCT. INDIC.	X-VALUE	DJ	COST*SCALE
94	PLUS	S46	*BASIS	20634.26440713+	. +	.00033000-
95	PLUS	S47	*BASIS	7733.54001122+	. +	.00122000-
96	RHS	RHSV		. +	145.75000338-	. +

Hill AFB Fuel Allocations, N=47

APPENDIX F

HILL AFB OPTIMAL OUTPUT

F1521 01 04/16/80 GENERATOR FUEL ALLOCATION PLAN VERB= PRIMAL PAGE 17

RPNAME=RFP : : FUNCT= 1.72794324+ OBJ=TIME : : RHS=RHSV : :

ITER	FTA	NUO	FUNCTIONAL	NINFS	NOJS	VALUE?	INCOMING	VECTOR	NAME	IN	KJ	OUT	KJ	CCT	VPC	ACT	NCT	FCT	A.TIM
1	1	1	1.72794324+	36	5	2818.41958-	S1	:	:	P	47S	Z	2L	1	10	1A	1	6	.144
2	2	2	2.25919265+	35		2768.50879-	S7	:	:	P	53S	Z	7L	2		1A	1	6	.24
3	3	3	2.41988988+	34		2751.53918-	S4	:	:	P	58S	Z	4L	3		1A	1	6	.18
4	4	4	2.43984988+	34		2751.53918-	S9	:	:	P	55S	Z	9L	4		1A	1	6	.17
5	5	5	5.45924868+	33	5	2469.33658-	S12	:	:	P	58S	Z	13L	1	10	1A	1	11	.42
6	6	6	6.81994155+	32		2775.31517-	S15	:	:	P	41S	Z	15L	2		1A	1	11	.21
7	7	7	8.68114467+	31		2189.84833-	S18	:	:	P	64S	Z	18L	3		1A	1	11	.28
8	8	8	11.0795459+	30		1993.48472-	S17	:	:	P	63S	Z	17L	4		1A	1	11	.17
9	9	9	11.9750925+	29		1949.48472-	S21	:	:	P	66S	Z	21L	5		1A	1	11	.15
10	10	10	14.2763945+	28	5	1697.51892-	S38	:	:	P	74S	Z	29L	1	8	1A	1	16	.38
11	11	11	15.9315743+	27		1673.64592-	S22	:	:	P	67S	Z	22L	2		1A	1	16	.19
12	12	12	16.1322533+	26		1597.62393-	S25	:	:	P	69S	Z	23L	3		1A	1	16	.20
13	13	13	18.1341297+	25	5	1587.44792-	S33	:	:	P	77S	Z	32L	1	7	1A	1	21	.41
14	14	14	18.7462578+	24	5	1467.44792-	S47	:	:	P	91S	Z	45L	1	10	1A	1	26	.45
15	15	15	18.7481343+	23		1467.27192-	S41	:	:	P	85S	Z	39L	2		1A	1	26	.19
16	16	16	21.8769419+	22	5	1328.21312-	S6	:	:	P	52S	Z	8L	1	14	2A	1	31	.47
17	17	17	22.3216462+	21		1299.38412-	S3	:	:	P	49S	Z	3L	2		2A	1	31	.19
18	18	18	22.5962185+	20		1288.13823-	S14	:	:	P	60S	Z	16L	3		2A	1	31	.10
19	19	19	30.8434959+	19	6	1148.79518-	S16	:	:	P	62S	Z	19L	1	20	2A	2	36	.58
20	20	20	32.1155899+	18		1095.43518-	S23	:	:	P	68S	Z	24L	2		2A	2	36	.28
21	21	21	32.1155899+	18		1095.43538-	S36	:	:	P	88S	Z	35L	3		2A	2	36	.16
22	22	22	32.3273128+	17	6	1094.88538-	S40	:	:	P	84S	Z	38L	1	10	2A	2	41	.48
23	23	23	32.3378571+	16		1074.42758-	S37	:	:	P	81S	Z	34L	2		2A	2	41	.23
24	24	24	42.3332876+	15	6	977.003264-	S2	:	:	P	48S	Z	5L	1	26	3A	2	46	.57
25	25	25	46.3559391+	14		981.245605-	S26	:	:	P	70S	Z	25L	2		3A	2	46	.20
26	26	26	49.5898719+	13		825.488886-	S8	:	:	P	54S	Z	6L	3		3A	2	46	.18
27	27	27	58.8383683+	12		885.441486-	S27	:	:	P	71S	Z	26L	4		3A	2	46	.18
28	28	28	62.3589186+	11	11	651.245598-	S28	:	:	P	72S	Z	27L	1	45	4A	2	51	.50
29	29	29	83.3979149+	10		541.397182-	S5	:	:	P	51S	Z	10L	2		4A	2	51	.20
30	30	30	83.4835377+	9		541.221108-	S35	:	:	P	79S	Z	33L	3		4A	2	51	.17
31	31	31	83.4835377+	9		541.221108-	S39	:	:	P	83S	Z	37L	4		4A	2	51	.14
32	32	32	105.454811+	8	8	437.611408-	S10	:	:	P	56S	Z	11L	1	30	5A	3	56	.55
33	33	33	105.460148+	7		437.511208-	S34	:	:	P	78S	Z	36L	2		5A	3	56	.74
34	34	34	105.589288+	6	7	436.994688-	S38	:	:	P	82S	Z	31L	1	45	6A	2	61	.57
35	35	35	129.221275+	5	7	214.311191-	S32	:	:	P	76S	Z	40L	1	45	7A	2	66	.43
36	36	36	129.221275+	5	6	214.311191-	S42	:	:	P	86S	Z	41L	1	45	8A	2	71	.50
37	37	37	129.221275+	5	5	214.311191-	S43	:	:	P	87S	Z	42L	1	45	9A	1	76	.62
38	38	38	129.221275+	5	4	214.311191-	S44	:	:	P	88S	Z	43L	1	45	10A		80	.41
39	39	39	129.221275+	5	1	214.311191-	S45	:	:	P	89S	Z	44L	1	90	12B		84	.91
40	40	40	143.151338+	4	1	177.547802-	S46	:	:	P	98S	Z	30L	1	45	13B		85	.49
41	41	41	172.997854+	3	1	95.4490816-	S31	:	:	P	75S	Z	28L	1	45	14B		86	.47
42	42	42	181.954435+	2	1	79.4499128-	S29	:	:	P	73S	Z	20L	1	45	15B		87	.53
43	43	43	217.517624+	1	1	52.0361995-	S20	:	:	P	65S	Z	14L	1	45	16B		88	.51
44	44	44	287.428398+		1	.153888883-	S13	:	:	P	59S	Z	12L	1	45	17A		89	.53
45	45	45	336.131286+		1	.309366085-	S11	:	:	P	57S	P	1L	1	45	18A		90	.44

14 RINV INVEPT DOINV DEMAND 36527 35365 14

15 CURNT CURRENT 35570 17

OPTIMAL SOLUTION

Hill AFB Iterations, N=45

F1527 01 04/16/80 GENERATOR FUEL ALLOCATION PLAN VERB= OUTPUT PAGE 28

PRMAN=OFP : : FUNCT= 336.131286+ OBJ=TIME : : RHS=RHSV : :

ROWS

SLACK VALUES

ROW KJ	TYPE	ROW NAME	LOGICAL INDIC.	L-VALUE		PI	RHS
1	PLUS	FUEL		.	.	.00149586+	215712.00000000+
2	ZERO	TC1		.	.	.02061252-	81.16879940+
3	ZERO	TC2		.	.	.01247755-	10.45450008-
4	ZERO	TC3		.	.	.00992589-	8.40480010-
5	ZERO	TC4		.	.	.00642438+	136.36359077+
6	ZERO	TC5		.	.	.02277466+	111.48828876-
7	ZERO	TC6		.	.	.03441124+	74.95540073-
8	ZERO	TC7		.	.	.05276151+	98.48479938+
9	ZERO	TC8		.	.	.46805884+	. .
10	ZERO	TC9		.	.	.00335457+	147.72729873+
11	ZERO	TC10		.	.	.39148955+	103.60969925+
12	ZERO	TC11		.	.	.10512613+	193.63750076-
13	ZERO	TC12		.	.	.00978625+	141.68129928+
14	ZERO	TC13		.	.	.10132158+	78.80868016-
15	ZERO	TC14		.	.	.11767185+	64.98840046-
16	ZERO	TC15		.	.	.06558437+	140.74599838+
17	ZERO	TC16		.	.	.00193464+	58.19188836-
18	ZERO	TC17		.	.	.00307884+	82.73348034-
19	ZERO	TC18		.	.	.10060537+	228.03639984+
20	ZERO	TC20		.	.	.10874035+	246.63640022-
21	ZERO	TC21		.	.	.10987575+	42.00000000+
22	ZERO	TC22		.	.	.11621708+	36.95849957+
23	ZERO	TC23		.	.	.10328864+	17.99100017-
24	ZERO	TC25		.	.	.00108960+	44.67889997+
25	ZERO	TC26		.	.	.08914457+	37.97879991+
26	ZERO	TC27		.	.	.10549485+	18.02329993+
27	ZERO	TC28		.	.	.11783017+	77.09789943+
28	ZERO	TC29		.	.	.12516515+	103.00000101-
29	ZERO	TC30		.	.	.13294312+	105.90289966+
30	ZERO	TC31		.	.	.14447845+	153.10718144-
31	ZERO	TC32		.	.	.15811583+	.39440008-
32	ZERO	TC33		.	.	.15925843+	.08890000+
33	ZERO	TC34		.	.	.16739540+	.08800000-
34	ZERO	TC35		.	.	.16852080+	.22890800-
35	ZERO	TC36		.	.	.18487188+	. .
36	ZERO	TC37		.	.	.20122135+	.36700000+
37	ZERO	TC38		.	.	.21875669+	. .
38	ZERO	TC39		.	.	.23629282+	.27580000-
39	ZERO	TC40		.	.	.24442780+	.08800000-
40	ZERO	TC41		.	.	.24556240+	111.96299934+
41	ZERO	TC42		.	.	.21885738+	. .
42	ZERO	TC43		.	.	.19824486+	. .
43	ZERO	TC44		.	.	.10017550+	. .
44	ZERO	TC45		.	.	.07956290+	. .
45	ZERO	TC46		.	.	.00402791+	120.00000000-

Hill AFB Slack Values, N=45

FISPT 01 04/16/88 GENERATOR FUEL ALLOCATION PLAN VERR= OUTPUT PAGE 22

PRNAME=AFP : : FUNCT= 336,131286+ OBJ=TIME : : RHS=RHSV : :

COLUMNS

FUEL ALLOCATIONS

COL	KJ	TYPE	Generator # COLUMN NAME	STRUCT. INDIC.	X-VALUE	DJ		COST*SCALE
	47	PLUS	S1	*BASIS	12406.80323370+	.	-	.00076000-
	48	PLUS	S2	*BASIS	3184.45486214+	.	+	.00242000-
	49	PLUS	S3	*BASIS	4652.60714325+	.	-	.00170000-
	50	PLUS	S4	*BASIS	1256.41374151+	.	-	.00645000-
	51	PLUS	S5	*BASIS	884.36884692+	.	+	.00645000-
	52	PLUS	S6	*BASIS	1014.06404017+	.	-	.00417000-
	53	PLUS	S7	*BASIS	1256.41370736+	.	-	.00645000-
	54	PLUS	S8	*BASIS	1120.83421264+	.	-	.00532000-
	55	PLUS	S9	*BASIS	1120.83421264+	.	+	.00532000-
	56	PLUS	S10	*BASIS	1103.81385166+	.	-	.00242000-
	57	PLUS	S11	*BASIS	157.42760049+	.	-	.00417000-
	58	PLUS	S12	*BASIS	5502.67209528+	.	-	.00087000-
	59	PLUS	S13	*BASIS	539.06210634+	.	-	.00327000-
	60	PLUS	S14	*BASIS	531.34100077+	.	-	.00645000-
	61	PLUS	S15	*BASIS	1469.34166656+	.	-	.00327000-
	62	PLUS	S16	*BASIS	1004.83340776+	.	-	.00645000-
	63	PLUS	S17	*BASIS	4894.01239478+	.	-	.00158000-
	64	PLUS	S18	*BASIS	1113.44920097+	.	-	.00051000-
	65	PLUS	S20	*BASIS	1913.23338620+	.	-	.00242000-
	66	PLUS	S21	*BASIS	6261.53451579+	.	-	.00158000-
	67	PLUS	S22	*BASIS	4219.79704338+	.	-	.00213000-
	68	PLUS	S23	*BASIS	8851.10889974+	.	-	.00093000-
	69	PLUS	S25	*BASIS	11601.57096986+	.	-	.00073000-
	70	PLUS	S26	*BASIS	3154.43038384+	.	-	.00242000-
	71	PLUS	S27	*BASIS	1057.63057361+	.	-	.00645000-
	72	PLUS	S28	*BASIS	2018.47324989+	.	-	.00327000-
	73	PLUS	S29	*BASIS	2054.07819098+	.	-	.00242000-
	74	PLUS	S30	*BASIS	3748.19155604+	.	-	.00236000-
	75	PLUS	S31	*BASIS	2019.47319371+	.	+	.00327000-
	76	PLUS	S32	*BASIS	2363.83619043+	.	+	.00417000-
	77	PLUS	S33	*BASIS	6741.03466026+	.	+	.00158000-
	78	PLUS	S34	*BASIS	4083.22767944+	.	-	.00242000-
	79	PLUS	S35	*BASIS	6261.03453026+	.	+	.00158000-
	80	PLUS	S36	*BASIS	1531.91931698+	.	+	.00645000-
	81	PLUS	S37	*BASIS	1531.91929906+	.	+	.00645000-
	82	PLUS	S38	*BASIS	1159.51135941+	.	+	.00051000-
	83	PLUS	S39	*BASIS	1159.51134061+	.	+	.00051000-
	84	PLUS	S40	*BASIS	4005.20717166+	.	+	.00242000-
	85	PLUS	S41	*BASIS	6264.06921735+	.	+	.00159000-
	86	PLUS	S42	*BASIS	11252.54071737+	.	+	.00066000-
	87	PLUS	S43	*BASIS	9065.67262849+	.	+	.00076000-
	88	PLUS	S44	*BASIS	28176.36135407+	.	+	.00027000-
	89	PLUS	S45	*BASIS	9865.67760792+	.	+	.00074000-
	90	PLUS	S46	*BASIS	22577.21210404+	.	+	.00033000-
	91	PLUS	S47	*BASIS	8263.09207284+	.	+	.00122000-

Hill AFB Fuel Allocations, N=45

APPENDIX G

McCLELLAN AFB INPUT PROGRAMS

McClellan AFB Adjusted Input Program

```
10##S,R(SL) :,8,16;;,16
15$:IDENT:WP1186, MOTT/NELSON THESIS
20$:USERID:80A053$KR79
25$:PROGRAM:RLHS
30$:LIMITS:10,39K,,5K
35$:PRMFL:H*,R,R,AF.LIB/LP.PAC
40$:REMOTE:SO,SL
45$:DISC:AA,A1,10R
50$:DISC:AB,A2,10R
55$:DISC:AC,A3,10R
60$:DISC:AD,A4,10R
65$:DISC:AE,A5,10R
70$:DATA:IN
75FILE:ELEC
80**** MCCLELLAN AFB FUEL PLAN ****
85****                        ****
90**** CONSTRAINT MATRIX ****
95****                   ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S2(P)=1
110:,S3(P)=1
115:,S4(P)=1
120:,S5(P)=1
125:,S6(P)=1
130:,S10(P)=1
135:,S11(P)=1
140:,S12(P)=1
145:,S13(P)=1
150:,S14(P)=1
155:,S15(P)=1
160:,S16(P)=1
165:,S18(P)=1
170:,S19(P)=1
175:,S20(P)=1
180:,S21(P)=1
185:,S22(P)=1
190:,S23(P)=1
195:,S24(P)=1
200:,S25(P)=1
205:,S26(P)=1
210:,S27(P)=1
215:,S28(P)=1
220:,S29(P)=1
225:,S30(P)=1
230:,S31(P)=1
235:,S32(P)=1
240:,S33(P)=1
245:,S34(P)=1
250:,S35(P)=1
255:,S36(P)=1
```

```
260**** TIME EQUALITY CONSTRAINTS ****
265MATRIX:TC2(Z),S2=.0741
270:,S3=-.0357
275A:TC3(Z),S3=.0357
280:,S4=-.3030
285A:TC4(Z),S4=.3030
290:,S5=-.4
295A:TC5(Z),S5=.4000
300:,S6=-.0074
305A:TC6(Z),S6=.0074
310:,S10=-.4
315A:TC10(Z),S10=.4000
320:,S11=-.0568
325A:TC11(Z),S11=.0568
330:,S12=-.1961
335A:TC12(Z),S12=.1961
340:,S13=-.3030
345A:TC13(Z),S13=.3030
350:,S14=-.4
355A:TC14(Z),S14=.4000
360:,S15=-.1961
365A:TC15(Z),S15=.1961
370:,S16=-.0980
375A:TC16(Z),S16=.0980
380:,S18=-.1961
385A:TC18(Z),S18=.1961
390:,S19=-.1136
395A:TC19(Z),S19=.1136
400:,S20=-.1961
405A:TC20(Z),S20=.1961
410:,S21=-.1136
415A:TC21(Z),S21=.1136
420:,S22=-.0741
425A:TC22(Z),S22=.0741
430:,S23=-.1136
435A:TC23(Z),S23=.1136
440:,S24=-.1961
445A:TC24(Z),S24=.1961
450:,S25=-.1136
455A:TC25(Z),S25=.1136
460:,S26=-.0741
465A:TC26(Z),S26=.0741
470:,S27=-.3030
475A:TC27(Z),S27=.3030
480:,S28=-.1961
485A:TC28(Z),S28=.1961
490:,S29=-.1961
495A:TC29(Z),S29=.1961
500:,S30=-.1136
505A:TC30(Z),S30=.1136
510:,S31=-.0741
```

```
515A:TC31(Z),S31=.0741
520:,S32=-.1961
525A:TC32(Z),S32=.1961
530:,S33=-.1961
535A:TC33(Z),S33=.1961
540:,S34=-.1136
545A:TC34(Z),S34=.1136
550:,S35=-.0125
555A:TC35(Z),S35=.0125
560:,S36=-.1905
565****                                ****
570****  OBJECTIVE FUNCTION            ****
575****                                ****
580MATRIX:TIME(FREE),S2=-.00206
585:,S3=-.00099
590:,S4=-.00842
595:,S5=-.01111
600:,S6=-.000206
605:,S10=-.01111
610:,S11=-.00158
615:,S12=-.00545
620:,S13=-.00842
625:,S14=-.01111
630:,S15=-.00545
635:,S16=-.00272
640:,S18=-.00546
645:,S19=-.00316
650:,S20=-.00545
655:,S21=-.00316
660:,S22=-.00206
665:,S23=-.00316
670:,S24=-.00545
675:,S25=-.00316
680:,S26=-.00206
685:,S27=-.00842
690:,S28=-.00545
695:,S29=-.00545
700:,S30=-.00316
705:,S31=-.00216
710:,S32=-.00545
715:,S33=-.00545
720:,S34=-.00316
725:,S35=-.00035
730:,S36=-.00529
735****                                 ****
740****   RIGHT HAND SIDE VALUES        ****
745****                                 ****
750****   FUEL QUANTITY CONSTRAINT      ****
755RHS:FUEL,RHSV=122976
760****   TIME EQUALITY CONSTRAINTS     ****
765:TC2=-38.3598
```

```
770:TC3=29.4372
775:TC4=34.8485
780:TC5=48.1481
785:TC6=-48.1481
790:TC10=184.0909
795:TC11=-275.6595
800:TC12=-.5526
805:TC13=.5212
810:TC14=.0314
815:TC15=236.6667
820:TC16=-236.6666
825:TC18=54.0660
830:TC19=-33.0882
835:TC20=-21.4573
840:TC21=-.0286
845:TC22=.0286
850:TC23=13.5028
855:TC24=-13.5028
860:TC25=-.0286
865:TC26=-.0471
870:TC27=.5526
875:TC28=0
880:TC29=-.4769
885:TC30=-.0289
890:TC31=.5055
895:TC32=0
900:TC33=-.4769
905:TC34=112.0455
910:TC35=-120
915END***
920$:DATA:I*
925:PREPRO
930:TITLE:GENERATOR FUEL ALLOCATION PLAN
935:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
940:SETUP:SOURCE=GFP
945:SET:OBJ=TIME,RHS=RHSV
950:PICTURE
955:PRIMAL
960:OUTPUT
965:ENDLP
970$:ENDJOB
975***EOF
```

<u>McClellan AFB Original Input Program</u>

```
10##S.R(J) :,8,16;;,16
15$:IDENT:WP1186, MOTT/NELSON THESIS
20$:USERID:80A053$KR79
25$:PROGRAM:RLHS
30$:LIMITS:10,39K,,5K
35$:PRMFL:H*,R,R,AF.LIB/LP.PAC
40$:REMOTE:SO,SL
45$:DISC:AA,A1,10R
50$:DISC:AB,A2,10R
55$:DISC:AC,A3,10R
60$:DISC:AD,A4,10R
65$:DISC:AE,A5,10R
70$:DATA:IN
75FILE:ELEC
80**** MCCLELLAN AFB FUEL PLAN ****
85****                        ****
90**** CONSTRAINT MATRIX ****
95****                   ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S1(P)=1
110:,S2(P)=1
115:,S3(P)=1
120:,S4(P)=1
125:,S5(P)=1
130:,S6(P)=1
135:,S7(P)=1
140:,S8(P)=1
145:,S9(P)=1
150:,S10(P)=1
155:,S11(P)=1
160:,S12(P)=1
165:,S13(P)=1
170:,S14(P)=1
175:,S15(P)=1
180:,S16(P)=1
185:,S17(P)=1
190:,S18(P)=1
195:,S19(P)=1
200:,S20(P)=1
205:,S21(P)=1
210:,S22(P)=1
215:,S23(P)=1
220:,S24(P)=1
```

```
225:,S25(P)=1
230:,S26(P)=1
235:,S27(P)=1
240:,S28(P)=1
245:,S29(P)=1
250:,S30(P)=1
255:,S31(P)=1
260:,S32(P)=1
265:,S33(P)=1
270:,S34(P)=1
275:,S35(P)=1
280:,S36(P)=1
285**** TIME EQUALITY CONSTRAINTS ****
290MATRIX:TC1(Z),S1=.0408
295:,S2=-.0741
300A:TC2(Z),S2=.0741
305:,S3=-.0357
310A:TC3(Z),S3=.0357
315:,S4=-.3030
320A:TC4(Z),S4=.3030
325:,S5=-.4
330A:TC5(Z),S5=.4000
335:,S6=-.0074
340A:TC6(Z),S6=.0074
345:,S7=-.0069
350A:TC7(Z),S7=.0069
355:,S8=-.0060
360A:TC8(Z),S8=.0060
365:,S9=-.1961
370A:TC9(Z),S9=.1961
375:,S10=-.4
380A:TC10(Z),S10=.4000
385:,S11=-.0568
390A:TC11(Z),S11=.0568
395:,S12=-.1961
400A:TC12(Z),S12=.1961
405:,S13=-.3030
410A:TC13(Z),S13=.3030
415:,S14=-.4
420A:TC14(Z),S14=.4000
425:,S15=-.1961
430A:TC15(Z),S15=.1961
435:,S16=-.0980
440A:TC16(Z),S16=.0980
445:,S17=-.7692
450A:TC17(Z),S17=.7692
455:,S18=-.1961
460A:TC18(Z),S18=.1961
465:,S19=-.1136
470A:TC19(Z),S19=.1136
475:,S20=-.1961
```

```
480A:TC20(Z),S20=.1961
485:,S21=-.1136
490A:TC21(Z),S21=.1136
495:,S22=-.0741
500A:TC22(Z),S22=.0741
505:,S23=-.1136
510A:TC23(Z),S23=.1136
515:,S24=-.1961
520A:TC24(Z),S24=.1961
525:,S25=-.1136
530A:TC25(Z),S25=.1136
535:,S26=-.0741
540A:TC26(Z),S26=.0741
545:,S27=-.3030
550A:TC27(Z),S27=.3030
555:,S28=-.1961
560A:TC28(Z),S28=.1961
565:,S29=-.1961
570A:TC29(Z),S29=.1961
575:,S30=-.1136
580A:TC30(Z),S30=.1136
585:,S31=-.0741
590A:TC31(Z),S31=.0741
595:,S32=-.1961
600A:TC32(Z),S32=.1961
605:,S33=-.1961
610A:TC33(Z),S33=.1961
615:,S34=-.1136
620A:TC34(Z),S34=.1136
625:,S35=-.0125
630A:TC35(Z),S35=.0125
635:,S36=-.1905
640****                                        ****
645****  OBJECTIVE FUNCTION                   ****
650****                                       ****
655MATRIX:TIME(FREE),S1=-.00113
660:,S2=-.00206
665:,S3=-.00099
670:,S4=-.00842
675:,S5=-.01111
680:,S6=-.000206
685:,S7=-.000192
690:,S8=-.000167
695:,S9=-.00545
700:,S10=-.01111
705:,S11=-.00158
710:,S12=-.00545
715:,S13=-.00842
720:,S14=-.01111
725:,S15=-.00545
730:,S16=-.00272
```

```
735:,S17=-.02137
740:,S18=-.00546
745:,S19=-.00316
750:,S20=-.00545
755:,S21=-.00316
760:,S22=-.00206
765:,S23=-.00316
770:,S24=-.00545
775:,S25=-.00316
780:,S26=-.00206
785:,S27=-.00842
790:,S28=-.00545
795:,S29=-.00545
800:,S30=-.00316
805:,S31=-.00216
810:,S32=-.00545
815:,S33=-.00545
820:,S34=-.00316
825:,S35=-.00035
830:,S36=-.00529
835****                                  ****
840****   RIGHT HAND SIDE VALUES         ****
845****                                  ****
850****   FUEL QUANTITY CONSTRAINT       ****
855RHS:FUEL,RHSV=122976
860****   TIME EQUALITY CONSTRAINTS      ****
865:TC1=-252.4565
870:TC2=-38.3598
875:TC3=29.4372
880:TC4=34.8485
885:TC5=48.1481
890:TC6=196.6795
895:TC7=106.9796
900:TC8=38.3889
905:TC9=-390.1961
910:TC10=184.0909
915:TC11=-275.6595
920:TC12=-.5526
925:TC13=.5212
930:TC14=.0314
935:TC15=236.6667
940:TC16=139.5174
945:TC17=-376.1840
950:TC18=54.0660
955:TC19=-33.0882
960:TC20=-21.4573
965:TC21=-.0286
970:TC22=.0286
975:TC23=13.5028
980:TC24=-13.5028
985:TC25=-.0286
```

```
990:TC26=-.0471
995:TC27=.5526
1000:TC28=0
1005:TC29=-.4769
1010:TC30=-.0289
1015:TC31=.5055
1020:TC32=0
1025:TC33=-.4769
1030:TC34=112.0455
1035:TC35=-120
1040END***
1045$:DATA:I*
1050:PREPRO
1055:TITLE:GENERATOR FUEL ALLOCATION PLAN
1060:CONVERT:SOURCE=ELEC/IN.IDENT=GFP
1065:SETUP:SOURCE=GFP
1070:SET:OBJ=TIME,RHS=RHSV
1075:PICTURE
1080:PRIMAL
1085:OUTPUT
1090:ENDLP
1095$:ENDJOB
1100***EOF
```

APPENDIX H

McCLELLAN SUBOPTIMAL OUTPUT

C250T 91 04/14/80 GENERATOR FUEL ALLOCATION PLAN VERB= PRIMAL PAGE 17

PRNAM=OFP : : FUNCT= 11.4720039+ OBJ=TIME : : RHS=RHSV : :

ITER	ETA	NUM	FUNCTIONAL	NINFS	NOJS	VALUE2	INCOMING	VECTOR	NAME	IN	KJ	OUT	KJ	CCT	VPC	ACT	NCT	FCT	A.TIM
1	1	1	11.4720038+	32	5	2466.49768-	S1	:	:	P	38S	Z	2L	1	10	1A	1	6	.123
2	2	2	16.5951285+	31		2497.91589-	S18	:	:	P	47S	Z	11L	2		1A	1	6	.38
3	3	3	17.4014542+	30		2839.84149-	S3	:	:	P	40S	Z	4L	3		1A	1	6	.18
4	4	4	18.2660105+	29	5	1930.98948-	S18	:	:	P	55S	Z	19L	1	8	1A	1	11	.39
5	5	5	18.9212939+	28		1929.86709-	S13	:	:	P	50S	Z	14L	2		1A	1	11	.19
6	6	6	18.9234387+	26		1929.80429-	S14	:	:	P	51S	Z	15L	3		1A	1	11	.18
7	7	7	18.9363845+	25	5	1929.85049-	S34	:	:	P	71S	Z	34L	1	16	1A	1	16	.42
8	8	8	18.9376135+	24		1928.75628-	S27	:	:	P	64S	Z	27L	2		1A	1	16	.19
9	9	9	18.9384559+	23		1928.69848-	S31	:	:	P	68S	Z	31L	3		1A	1	16	.17
10	10	10	18.9392589+	21		1928.64129-	S22	:	:	P	59S	Z	22L	4		1A	1	16	.16
11	11	11	18.9408407+	20		1928.59489-	S26	:	:	P	63S	Z	26L	5		1A	1	16	.14
12	12	12	22.2731242+	19	5	1889.58449-	S36	:	:	P	73S	Z	36L	1	13	2A	1	21	.37
13	13	13	22.7685058+	18		1790.73889-	S4	:	:	P	41S	Z	3L	2		2A	1	21	.17
14	14	14	22.8882821+	17	6	1789.78509-	S25	:	:	P	62S	Z	28L	1	14	2A	2	26	.47
15	15	15	25.6064776+	16	6	1763.85919-	S2	:	:	P	39S	Z	5L	1	19	3A	2	31	.52
16	16	16	25.7136288+	15		1762.98599-	S10	:	:	P	67S	Z	32L	2		3A	2	31	.17
17	17	17	25.7136288+	15	6	1762.98599-	S21	:	:	P	58S	Z	23L	1	15	3A	2	36	.44
18	18	18	26.8402216+	14		1735.98839-	S23	:	:	P	60S	Z	24L	2		3A	2	36	.17
19	19	19	33.5227551+	13	11	1687.75229-	S5	:	:	P	42S	Z	6L	1	33	4A	1	41	.52
20	20	20	33.5227551+	13	9	1687.75229-	S28	:	:	P	65S	Z	29L	1	28	5A	3	46	.58
21	21	21	33.5227551+	13	10	1687.75229-	S32	:	:	P	69S	Z	33L	1	36	6A	2	51	.53
22	22	22	33.5227971+	12		1687.75169-	S33	:	:	P	70S	Z	30L	2		6A	2	51	.18
23	23	23	37.1516779+	11	9	1661.60909-	S29	:	:	P	66S	Z	25L	1	36	7A	3	56	.52
24	24	24	40.2685728+	10		1645.79899-	S24	:	:	P	61S	Z	21L	2		7A	3	56	.19
25	25	25	54.1118564+	9	7	1579.61450-	S20	:	:	P	57S	Z	20L	1	35	8A	3	61	.56
26	26	26	81.3687391+	8	8	1464.61508-	S19	:	:	P	56S	Z	35L	1	36	9A	2	66	.45
27	27	27	221.564592+	7	8	1199.99679-	S35	:	:	P	72S	Z	18L	1	36	10A	2	71	.57
28	28	28	221.564592+	7	7	1199.99679-	S12	:	:	P	49S	Z	13L	1	36	11A	3	76	.61
29	29	29	247.869543+	6		726.663391-	S15	:	:	P	52S	Z	16L	2		11A	3	76	.16
30	30	30	253.285749+	5		648.677803-	S16	:	:	P	53S	Z	12L	3		11A	3	76	.15
31	31	31	272.537258+	4		447.628582-	S11	:	:	P	48S	Z	17L	4		11A	3	76	.15
32	32	32	292.312317+	4	4	330.751823-	S6	:	:	P	43S	P	1L	1	36	12A		80	.52
14	RINV	INVERT									DOINV		DEMAND 36527					44871	13
15	CURNT	CURRENT																44875	14
45		PRIMAL																44875	14

McClellan AFB Iterations, N=36--Suboptimal Solution

C250T 01 04/14/80 GENERATOR FUEL ALLOCATION PLAN VERR= OUTPUT PAGE 19

PRNAM=GFP I I FUNCT= 292.312317+ OBJ=TIME I I RHS=RHSV I I

ROWS

SLACK VALUES

ROW KJ	TYPE	ROW NAME	LOGICAL INDIC.	L-VALUE	PI	RHS
1	PLUS	FUEL		. .	.00483204+	122976.00000000+
2	ZERO	TC1		. .	.11843245-	414.21839963+
3	ZERO	TC2		. .	.18364277-	38.35980834-
4	ZERO	TC3		. .	.31899368-	29.43719983+
5	ZERO	TC4		. .	.33494095-	34.84949977+
6	ZERO	TC5		. .	.34782186-	48.14809990+
7	ZERO	TC6	•BASIS (	79.88274845+)	1.00000000-	196.67949867+
8	ZERO	TC7	•BASIS (	106.97959995+)	1.00000000-	106.97959995+
9	ZERO	TC8	•BASIS (	38.38869980+)	1.00000000-	38.38869980+
10	ZERO	TC9	•BASIS (	105.58058639-)	1.00000000+	398.19610214-
11	ZERO	TC10		. .	.98791990+	184.89889851+
12	ZERO	TC11		. .	.98284873+	275.65950812-
13	ZERO	TC12		. .	.87820000+	.55260000-
14	ZERO	TC13		. .	.86226067+	.52119999+
15	ZERO	TC14		. .	.85018057+	.83140000+
16	ZERO	TC15		. .	.82553986+	236.66669845+
17	ZERO	TC16		. .	.77623330+	139.51739883+
18	ZERO	TC17		. .	1.05120371+	376.10400192-
19	ZERO	TC18		. .	1.02656381+	54.86599998+
20	ZERO	TC19		. .	.98402742+	33.88820889-
21	ZERO	TC20		. .	.95938671+	21.45738818-
22	ZERO	TC21		. .	.91585112+	.02860000-
23	ZERO	TC22		. .	.85164136+	.02860000+
24	ZERO	TC23		. .	.90918577+	13.50279999+
25	ZERO	TC24		. .	.78446586+	13.50280010-
26	ZERO	TC25		. .	.74192947+	.02860000-
27	ZERO	TC26		. .	.67671971+	.04710000-
28	ZERO	TC27		. .	.66077237+	.55259999+
29	ZERO	TC28		. .	.63613167+	. .
30	ZERO	TC29		. .	.61149096+	.47690000-
31	ZERO	TC30		. .	.56895536+	.02890000-
32	ZERO	TC31		. .	.58374560+	.58549999+
33	ZERO	TC32		. .	.47910489+	. .
34	ZERO	TC33		. .	.45446418+	.47690000-
35	ZERO	TC34		. .	.41192850+	112.04549980+
36	ZERO	TC35		. .	.02536586+	120.00000000-
37	FREE	TIME	•BASIS	292.31231729+	. .	. .

McClellan AFB Slack Values, N=36

PRNAM=GFP : : FUNCT= 292.312317+ OBJ=TIME : : RHS=RHSV : :

COLUMNS

Fuel Allocations

Generator #

COL KJ	TYPE	COLUMN NAME	STRUCT. INDIC.	X-VALUE		DJ		COST•SCALE	
38	PLUS	S1	•BASIS	14032.36169389	•	.	-	.00113000	-
39	PLUS	S2	•BASIS	2576.93348989	•	.	-	.00206000	-
40	PLUS	S3	•BASIS	6423.26587952	•	.	-	.00099000	-
41	PLUS	S4	•BASIS	659.64805533	•	.	•	.00047000	-
42	PLUS	S5	•BASIS	412.56214913	•	.	-	.01111000	-
43	PLUS	S6	•BASIS	15794.15663587	•	.	-	.00020600	-
44	PLUS	S7		.	•	.00483204	•	.00019200	-
45	PLUS	S8		.	•	.00483204	•	.00016700	-
46	PLUS	S9		.	•	.39703204	•	.00545000	-
47	PLUS	S10	•BASIS	711.53878541	•	.	-	.01111000	-
48	PLUS	S11	•BASIS	1769.79954112	•	.	-	.00150000	-
49	PLUS	S12	•BASIS	1910.32796189	•	.	-	.00545000	-
50	PLUS	S13	•BASIS	1243.35546690	•	.	-	.00042000	-
51	PLUS	S14	•BASIS	940.53075097	•	.	-	.01111000	-
52	PLUS	S15	•BASIS	1918.32790224	•	.	-	.00545000	-
53	PLUS	S16	•BASIS	1423.64693705	•	.	-	.00272000	-
54	PLUS	S17		.	•	.21633028	•	.02137000	-
55	PLUS	S18	•BASIS	1910.32739093	•	.	•	.00546000	-
56	PLUS	S19	•BASIS	2835.54574190	•	.	•	.00316000	-
57	PLUS	S20	•BASIS	1811.35234720	•	.	•	.00545000	-
58	PLUS	S21	•BASIS	3315.69973748	•	.	•	.00316000	-
59	PLUS	S22	•BASIS	5083.54390764	•	.	•	.00206000	-
60	PLUS	S23	•BASIS	3315.69966062	•	.	•	.00316000	-
61	PLUS	S24	•BASIS	1851.91576333	•	.	•	.00545000	-
62	PLUS	S25	•BASIS	3315.69961212	•	.	•	.00316000	-
63	PLUS	S26	•BASIS	5083.56371546	•	.	•	.00206000	-
64	PLUS	S27	•BASIS	1243.34358651	•	.	•	.00042000	-
65	PLUS	S28	•BASIS	1918.34046597	•	.	•	.00545000	-
66	PLUS	S29	•BASIS	1910.34044775	•	.	•	.00545000	-
67	PLUS	S30	•BASIS	3315.69943962	•	.	•	.00316000	-
68	PLUS	S31	•BASIS	5083.56749958	•	.	•	.00216000	-
69	PLUS	S32	•BASIS	1910.34191949	•	.	•	.00545000	-
70	PLUS	S33	•BASIS	1910.34190127	•	.	•	.00545000	-
71	PLUS	S34	•BASIS	3315.70194873	•	.	•	.00316000	-
72	PLUS	S35	•BASIS	21169.45915665	•	.	•	.00035000	-
73	PLUS	S36	•BASIS	2018.99337259	•	.	•	.00529000	-
74	RHS	RHSV		.	•	338.75102659	-	.	•

McClellan AFB Fuel Allocations, N=36

APPENDIX I

McCLELLAN AFB OPTIMAL OUTPUT

F009T 01 04/16/80 GENERATOR FUEL ALLOCATION PLAN VERB= PRIMAL PAGE 17

PRNAM=GFP : : FUNCT= 1.58535625+ OBJ=TIME : : RHS=PHSV : :

ITER	FTA	NUM	FUNCTIONAL	NINFS	NOJS	VALUE2	INCOMING	VECTOR NAME	IN	KJ	OUT	FJ	CCT	VPC	ACT	NCT	FCT	A.TIM
1	1	1	1.58535625+	27	5	1394.8[illegible]38-	S18 :	:	P	45S	Z	14L	1	13	1A	1	6	.128
2	2	2	2.84266972+	26		1298.53869-	S18 :	:	P	38S	Z	6L	2		1A	1	6	.37
3	3	3	3.65399545+	25		1239.66429-	S3 :	:	P	34S	Z	3L	3		1A	1	6	.10
4	4	4	3.67347896+	24		1238.62188-	S13 :	:	P	41S	Z	10L	4		1A	1	6	.20
5	5	5	3.67522368+	22		1238.55909-	S14 :	:	P	42S	Z	11L	5		1A	1	6	.16
6	6	6	3.68948955+	21	5	1237.68528-	S34 :	:	P	61S	Z	29L	1	16	1A	1	11	.42
7	7	7	3.68979838+	20		1237.51199-	S27 :	:	P	54S	Z	22L	2		1A	1	11	.10
8	8	8	3.67764903+	19		1237.45329-	S31 :	:	P	58S	Z	26L	3		1A	1	11	.17
9	9	9	3.69143598+	17		1237.39689-	S22 :	:	P	49S	Z	17L	4		1A	1	11	.15
10	10	10	3.69302577+	16		1237.33898-	S26 :	:	P	53S	Z	21L	5		1A	1	11	.13
11	11	11	7.02[illegible]30920+	15	5	1117.33898-	S36 :	:	P	63S	Z	31L	1	18	2A	1	16	.39
12	12	12	7.52069080+	14		1099.40368-	S4 :	:	P	35S	Z	2L	2		2A	1	16	.20
13	13	13	9.68084049+	13	5	1073.56779-	S2 :	:	P	33S	Z	4L	1	20	3A	1	21	.56
14	14	14	9.72161681+	12		1072.61398-	S25 :	:	P	52S	Z	23L	2		3A	1	21	.18
15	15	15	9.74776709+	11		1071.66079-	S30 :	:	P	57S	Z	27L	3		3A	1	21	.17
16	16	16	9.74776709+	11	7	1071.66079-	S28 :	:	P	55S	Z	24L	1	23	3A	3	26	.57
17	17	17	15.0967872+	10	7	1023.51269-	S5 :	:	P	36S	Z	5L	1	31	4A	3	31	.50
18	18	18	15.0967872+	10	7	1023.51269-	S32 :	:	P	59S	Z	28L	1	31	5A	3	36	.56
19	19	19	15.0968293+	9		1023.51289-	S33 :	:	P	68S	Z	25L	2		5A	3	36	.19
20	20	20	18.7357096+	8	6	997.461296-	S29 :	:	P	56S	Z	20L	1	31	6A	2	41	.51
21	21	21	41.3984594+	7	5	861.517494-	S6 :	:	P	37S	Z	7L	1	31	7A	1	46	.57
22	22	22	41.3984594+	7	4	841.517494-	S21 :	:	P	48S	Z	18L	1	31	8A		50	.47
23	23	23	42.5258538+	6		834.511894-	S23 :	:	P	50S	Z	19L	2		8A		50	.15
24	24	24	45.6319488+	5	3	819.602897-	S24 :	:	P	51S	Z	16L	1	31	9A		53	.40
25	25	25	59.4752321+	4	3	752.426586-	S20 :	:	P	47S	Z	15L	1	31	10A		56	.51
26	26	26	86.7321148+	3	3	637.427078-	S19 :	:	P	46S	Z	30L	1	31	11A		59	.52
27	27	27	153.011076+	2	3	512.326195-	S35 :	:	P	62S	Z	13L	1	31	12A		62	.51
28	28	28	153.011076+	2	2	512.326195-	S12 :	:	P	40S	Z	9L	1	31	13A		64	.40
29	29	29	179.316028+	1		38.9927916-	S15 :	:	P	43S	Z	12L	2		13A		64	.12
30	30	30	285.390774+		1	.098000005-	S16 :	:	P	44S	Z	8L	1	31	14A		65	.41
31	31	31	278.454552+		1	.049031562-	S11 :	:	P	39S	P	1L	1	31	15A		66	.51
14 RINV		INVERT								DOINV			DEMAND 36527				32722	12
15 CURNT		CURRENT															32727	13
45		PRIMAL															32728	14

OPTIMAL SOLUTION

McClellan AFB Iterations, N=31

FOROT 41 04/16/80 GENERATOR FUEL ALLOCATION PLAN VERR= OUTPUT PAGE 19

PRNAME=GFP : : FUNCT= 278.654552+ OBJ=TIME : : RHS=RHSV : :

SLACK VALUES

RIGHT-HAND SIDE VALUES

ROWS

ROW KJ	TYPE	ROW NAME	LOGICAL INDIC.	L-VALUE		PI	RHS
1	PLUS	FUEL		.	.	.00193420+	122976.00000000+
2	ZERO	TC2		.	.	.00169772+	38.35980034-
3	ZERO	TC3		.	.	.02475043-	29.43719983+
4	ZERO	TC4		.	.	.00334515-	34.84849977+
5	ZERO	TC5		.	.	.01959435+	48.14809998+
6	ZERO	TC6		.	.	.21394606-	48.14810037-
7	ZERO	TC10		.	.	.19100656-	184.09809851+
8	ZERO	TC11		.	.	.19724246-	275.65950012-
9	ZERO	TC12		.	.	.17931385-	.55260000-
10	ZERO	TC13		.	.	.15790857-	.52119999+
11	ZERO	TC14		.	.	.13496907-	.03140000+
12	ZERO	TC15		.	.	.11704846-	236.66649845+
13	ZERO	TC16		.	.	.10902298-	236.66660118-
14	ZERO	TC18		.	.	.09104248-	54.06599998+
15	ZERO	TC19		.	.	.08875199-	33.08820009-
16	ZERO	TC20		.	.	.06232336-	21.45730018-
17	ZERO	TC21		.	.	.05153286-	.02860000-
18	ZERO	TC22		.	.	.04983515-	.02960000+
19	ZERO	TC23		.	.	.03984464-	13.58279999+
20	ZERO	TC24		.	.	.02111603-	13.58280010-
21	ZERO	TC25		.	.	.01032553-	.02860000-
22	ZERO	TC26		.	.	.00862781-	.04710000-
23	ZERO	TC27		.	.	.01277747+	.55259999+
24	ZERO	TC28		.	.	.03070688+	. +
25	ZERO	TC29		.	.	.04063469+	.47690000-
26	ZERO	TC30		.	.	.05942519+	.07890000-
27	ZERO	TC31		.	.	.06747244+	.50549999+
28	ZERO	TC32		.	.	.08040105+	. +
29	ZERO	TC33		.	.	.09032967+	.47690000-
30	ZERO	TC34		.	.	.10912017+	112.04549980+
31	ZERO	TC35		.	.	.01761575-	120.00000000-
32	FREE	TIME	*BASIS	278.65455403+		1.00000000+	. +

McClellan AFB Slack Values, N=31

FORMT 01 04/16/80 GENERATOR FUEL ALLOCATION PLAN VERB= OUTPUT PAGE 20

PRNAM=GEP : : FUNCT= 274.654552+ OBJ=TIME : : RHS=RHSV : :

COLUMNS

FUEL ALLOCATIONS

COL	KJ	TYPE	COLUMN NAME	STRUCT. INDIC.	X-VALUE	DJ		COST*SCALE
33	PLUS	S2		*BASIS	3979.59947805+	.	-	.00206000-
34	PLUS	S3		*BASIS	9334.68116929+	.	-	.00099000-
35	PLUS	S4		*BASIS	1002.67628313+	.	+	.00042000-
36	PLUS	S5		*BASIS	672.40602971+	.	+	.01111000-
37	PLUS	S6		*BASIS	29839.77174542+	.	-	.00020600-
38	PLUS	S10		*BASIS	672.40602030+	.	-	.01111000-
39	PLUS	S11		*BASIS	1494.21669104+	.	+	.00150000-
40	PLUS	S12		*BASIS	1538.50590256+	.	+	.00545000-
41	PLUS	S13		*BASIS	1191.69505252+	.	+	.00042000-
42	PLUS	S14		*BASIS	901.40599540+	.	-	.01111000-
43	PLUS	S15		*BASIS	1538.50584539+	.	-	.00545000-
44	PLUS	S16		*BASIS	1263.92137393+	.	+	.00272000-
45	PLUS	S18		*BASIS	1838.50532588+	.	+	.00546000-
46	PLUS	S19		*BASIS	2697.75430932+	.	-	.00316000-
47	PLUS	S20		*BASIS	1731.53028356+	.	+	.00545000-
48	PLUS	S21		*BASIS	3177.90030743+	.	-	.00316000-
49	PLUS	S22		*BASIS	4072.32090816+	.	-	.00206000-
50	PLUS	S23		*BASIS	3177.90024143+	.	-	.00316000-
51	PLUS	S24		*BASIS	1772.02370276+	.	-	.00545000-
52	PLUS	S25		*BASIS	3177.90010737+	.	-	.00316000-
53	PLUS	S26		*BASIS	4072.32072410+	.	-	.00206000-
54	PLUS	S27		*BASIS	1191.70317242+	.	-	.00042000-
55	PLUS	S28		*BASIS	1838.51040079+	.	-	.00545000-
56	PLUS	S29		*BASIS	1838.51039133+	.	+	.00545000-
57	PLUS	S30		*BASIS	3177.99002204+	.	-	.00316000-
58	PLUS	S31		*BASIS	4072.32451922+	.	+	.00216000-
59	PLUS	S32		*BASIS	1838.51986549+	.	+	.00545000-
60	PLUS	S33		*BASIS	1838.51984882+	.	+	.00545000-
61	PLUS	S34		*BASIS	3177.91053663+	.	+	.00316000-
62	PLUS	S35		*BASIS	19917.21001263+	.	+	.00035000-
63	PLUS	S36		*BASIS	1936.82484660+	.	+	.00529000-
64	RHS	RHSV			. +	270.65455403+		. +

McClellan AFB Allocations, N=31

APPENDIX J

TINKER AFB INPUT PROGRAMS

Tinker AFB Original Input Program

```
10##S,R(SL) :,8,16;;,16
20$:IDENT:WP1186, MOTT/NELSON THESIS
30$:USERID:80A053$KR79
40$:PROGRAM:RLHS
50$:LIMITS:10,39K,5K
60$:PRMFL:H*,R,R,AF.LIB/LP.PAC
70$:REMOTE:SO,SL
80$:DISC:AA,A1,10R
90$:DISC:AB,A2,10R
100$:DISC:AC,A3,10R
110$:DISC:AD,A4,10R
120$:DISC:AE,A5,10R
130$:DATA:IN
140FILE:ELEC
150****     TINKER AFB FUEL PLAN     ****
155****                               ****
160****    CONSTRAINT MATRIX
165****                               ****
170****  FUEL QUANTITY CONSTRAINT     ****
180MATRIX:FUEL(P),S1(P)=1
185:,S2(P)=1
190:,S3(P)=1
195:,S4(P)=1
200:,S5(P)=1
205:,S6(P)=1
210:,S7(P)=1
215:,S8(P)=1
220:,S9(P)=1
225:,S10(P)=1
230:,S11(P)=1
235:,S12(P)=1
240:,S13(P)=1
245:,S14(P)=1
250:,S15(P)=1
255:,S16(P)=1
260:,S17(P)=1
265:,S18(P)=1
270:,S19(P)=1
275:,S20(P)=1
280:,S21(P)=1
285:,S22(P)=1
290:,S23(P)=1
295:,S24(P)=1
300:,S25(P)=1
305:,S26(P)=1
310:,S27(P)=1
315:,S28(P)=1
```

```
320:,S29(P)=1
325:,S30(P)=1
330:,S31(P)=1
335:,S32(P)=1
340:,S33(P)=1
345:,S34(P)=1
350:,S35(P)=1
355:,S36(P)=1
360:,S37(P)=1
430****    TIME EQUALITY CONSTRAINTS     ****
435MATRIX:TC1(Z),S1=.00746
440:,S2=-.0357
445A:TC2(Z),S2=.0357
450:,S3=-.303
455A:TC3(Z),S3=.303
460:,S4=-.5882
465A:TC4(Z),S4=.5882
470:,S5=-.3333
475A:TC5(Z),S5=.3333
480:,S6=-.7692
485A:TC6(Z),S6=.7692
490:,S7=-.1961
495A:TC7(Z),S7=.1961
500:,S8=-.1136
510A:TC8(Z),S8=.1136
515:,S9=-.5882
520A:TC9(Z),S9=.5882
525:,S10=-.0568
530A:TC10(Z),S10=.0568
535:,S11=-.11364
540A:TC11(Z),S11=.11364
545:,S12=-.11364
550A:TC12(Z),S12=.11364
555:,S13=-.0741
565A:TC13(Z),S13=.0741
570:,S14=-.0741
575A:TC14(Z),S14=.0741
580:,S15=-.0741
585A:TC15(Z),S15=.0741
590:,S16=-.303
595A:TC16(Z),S16=.303
600:,S17=-.1961
605A:TC17(Z),S17=.1961
610:,S18=-.0217
615A:TC18(Z),S18=.0217
620:,S19=-.1961
625A:TC19(Z),S19=.1961
630:,S20=-.588
635A:TC20(Z),S20=.588
640:,S21=-.588
645A:TC21(Z),S21=.588
```

```
650:,S22=-.0286
655A:TC22(Z),S22=.0286
660:,S23=-.303
665A:TC23(Z),S23=.303
670:,S24=-.303
675A:TC24(Z),S24=.303
680:,S25=-.0303
685A:TC25(Z),S25=.0303
690:,S26=-.05263
695A:TC26(Z),S26=.05263
700:,S27=-.11364
710A:TC27(Z),S27=.11364
715:,S28=-.11364
720A:TC28(Z),S28=.11364
725:,S29=-.19608
730A:TC29(Z),S29=.19608
735:,S30=-.7692
740A:TC30(Z),S30=.7692
745:,S31=-.303
750A:TC31(Z),S31=.303
755:,S32=-.0417
760A:TC32(Z),S32=.0417
765:,S33=-.1250
770A:TC33(Z),S33=.1250
775:,S34=-.0125
780A:TC34(Z),S34=.0125
785:,S35=-.0125
790A:TC35(Z),S35=.0125
795:,S36=-.025
800A:TC36(Z),S36=.025
805:,S37=-.01465
995****                                          ****
1000***    OBJECTIVE FUNCTION                    ****
1005***                                          ****
1010MATRIX:TIME(FREE),S1=-.00202
1020:,S2=-.00097
1025:,S3=-.00819
1030:,S4=-.0159
1035:,S5=-.009
1040:,S6=-.02079
1045:,S7=-.0053
1050:,S8=-.00307
1055:,S9=-.0159
1060:,S10=-.00154
1065:,S11=-.00307
1070:,S12=-.00307
1075:,S13=-.002
1080:,S14=-.002
1085:,S15=-.002
1090:,S16=-.00819
1095:,S17=-.0053
```

```
1100:,S18=-.00059
1105:,S19=-.0053
1110:,S20=-.0159
1115:,S21=-.00077
1120:,S22=-.00819
1125:,S23=-.00819
1130:,S24=-.00082
1135:,S25=-.00142
1140:,S26=-.00307
1145:,S27=-.00307
1150:,S28=-.0053
1155:,S29=-.02079
1160:,S30=-.00819
1165:,S31=-.001126
1170:,S32=-.00338
1175:,S33=-.00034
1180:,S34=-.00034
1185:,S35=-.00034
1190:,S36=-.00068
1195:,S37=-.0004
1300***                                                   ****
1305***     RIGHT HAND SIDE VALUES                        ****
1310***                                                   ****
1315***     FUEL QUANTITY CONSTRAINT                      ****
1320RHS:FUEL,RHSV=23436
1325***     TIME EQUALIYT CONSTRAINTS                     ****
1330:TC1=-131.397
1335:TC2=65.476
1340:TC3=85.491
1345:TC4=-73.158
1350:TC5=115.872
1355:TC6=-157.616
1360:TC7=2.8962
1365:TC8=164.947
1370:TC9=520.053
1375:TC10=-673.92
1380:TC11=48.9202
1385:TC12=-48.8923
1390:TC13=0
1395:TC14=0
1400:TC15=.1044
1405:TC16=22.3617
1410:TC17=186.999
1415:TC18=-158.567
1420:TC19=147
1425:TC20=0
1430:TC21=-105.88
1435:TC22=203.03
1440:TC23=-299.394
1445:TC24=602.4236
1450:TC25=-592.902
```

```
1455:TC26=-5.2603
1460:TC27=0
1465:TC28=.6317
1470:TC29=7.6246
1475:TC30=-8.1237
1480:TC31=111.9697
1485:TC32=0
1490:TC33=0
1495:TC34=0
1500:TC35=0
1505:TC36=-120
1600END***
1615$:DATA:I*
1620:PREPRO
1625:TITLE:GENERATOR FUEL ALLOCATION PLAN
1630:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
1635:SETUP:SOURCE=GFP
1640:SET:OBJ=TIME,RHS=RHSV
1645:PICTURE
1650:PRIMAL
1655:OUTPUT
1660:ENDLP
1665$:ENDJOB
1670***EOF
```

Tinker AFB Adjusted Input Program

```
10##S,R(SL) :,8,16;;,16
15$:IDENT:WP1186, MOTT/NELSON THESIS
20$:USERID:80A053$KR79
25$:PROGRAM:RLHS
30$:LIMITS:10,39K,5K
35$:PRMFL:H*,R,R,AF.LIB/LP.PAC
40$:REMOTE:SO,SL
45$:DISC:AA,A1,10R
50$:DISC:AB,A2,10R
55$:DISC:AC,A3,10R
60$:DISC:AD,A4,10R
65$:DISC:AE,A5,10R
70$:DATA:IN
75FILE:ELEC
80****     TINKER AFB FUEL PLAN     ****
85****                              ****
90****    CONSTRAINT MATRIX
95****                              ****
100****  FUEL QUANTITY CONSTRAINT    ****
105MATRIX:FUEL(P),S2(P)=1
110:,S3(P)=1
115:,S5(P)=1
120:,S7(P)=1
125:,S8(P)=1
130:,S11(P)=1
135:,S12(P)=1
140:,S13(P)=1
145:,S14(P)=1
150:,S15(P)=1
155:,S16(P)=1
160:,S17(P)=1
165:,S19(P)=1
170:,S22(P)=1
175:,S24(P)=1
180:,S26(P)=1
185:,S27(P)=1
190:,S28(P)=1
195:,S29(P)=1
200:,S30(P)=1
205:,S31(P)=1
210:,S37(P)=1
215****    TIME EQUALITY CONSTRAINTS     ****
220MATRIX:TC2(Z),S2=.0357
225:,S3=-.303
230A:TC3(Z),S3=.303
235:,S5=-.3333
240A:TC5(Z),S5=.3333
245:,S7=-.1961
```

```
500:,S17=-.0053
505:,S19=-.0053
510:,S22=-.00819
515:,S24=-.00082
520:,S26=-.00307
525:,S27=-.00307
530:,S28=-.0053
535:,S29=-.02079
540:,S30=-.00819
545:,S31=-.001126
550:,S37=-.0004
555***                                                  ****
560***     RIGHT HAND SIDE VALUES                       ****
565***                                                  ****
570***     FUEL QUANTITY CONSTRAINT                     ****
575RHS:FUEL,RHSV=23436
580***     TIME EQUALITY CONSTRAINTS                    ****
585:TC2=65.476
590:TC3=12.333
595:TC5=-41.744
600:TC7=2.8962
605:TC8=-48.9202
610:TC11=48.9202
615:TC12=-48.8923
620:TC13=0
625:TC14=0
630:TC15=.1044
635:TC16=22.3617
640:TC17=28.432
645:TC19=41.176
650:TC22=-96.3636
655:TC24=9.5216
660:TC26=-5.2603
665:TC27=0
670:TC28=.6317
675:TC29=7.6246
680:TC30=-8.1237
685:TC31=-8.0303
690END***
695$:DATA:I*
700:PREPRO
705:TITLE:GENERATOR FUEL ALLOCATION PLAN
710:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
715:SETUP:SOURCE=GFP
720:SET:OBJ=TIME,RHS=RHSV
725:PICTURE
730:PRIMAL
735:OUTPUT
740:ENDLP
745$:ENDJOB
750***EOF
```

APPENDIX K

TINKER AFB SUBOPTIMAL OUTPUT

R711T 01 04/29/80 GENERATOR FUEL ALLOCATION PLAN VERB= PRIMAL PAGE 17

P.NAME=DFP : : FUNCT= 1.97546357+ OBJ=TIME : : RHS=RHSV : :

ITER	FTA	NUR	FUNCTIONAL	NINFS	NBJS	VALUE2	INCOMING	VECTOR	NAME	IN	KJ	OUT	KJ	CCT	VPC	ACT	NCT	FCT	A.TIM
1	1	1	1.97546357+	27	5	4514.59436-	S5	:	:	P	43S	Z	5L	1	13	1A	1	6	.123
2	2	2	3.75150334+	26		4383.64239-	S2	:	:	P	48S	Z	3L	2		1A	1	6	.28
3	3	3	5.07608914+	25		4285.88194-	S11	:	:	P	49S	Z	12L	3		1A	1	6	.18
4	4	4	5.15436482+	24		4290.00958-	S7	:	:	P	45S	Z	8L	4		1A	1	6	.16
5	5	5	5.15436482+	24		4290.80958-	S13	:	:	P	51S	Z	14L	5		1A	1	6	.13
6	6	6	5.96460604+	23	5	3681.22159-	S24	:	:	P	62S	Z	24L	1	11	1A	1	11	.36
7	7	7	9.93757903+	22		3387.22159-	S19	:	:	P	57S	Z	20L	2		1A	1	11	.18
8	8	8	10.2577610+	21		3175.46158-	S22	:	:	P	60S	Z	22L	3		1A	1	11	.16
9	9	9	10.2979508+	20	5	3159.21417-	S31	:	:	P	69S	Z	31L	1	10	1A	1	16	.38
10	10	10	40.6508145+	19	5	2849.77459-	S8	:	:	P	46S	Z	7L	1	11	2A	1	21	.43
11	11	11	52.2237781+	18		2717.93258-	S3	:	:	P	41S	Z	2L	2		2A	1	21	.18
12	12	12	55.5102208+	17		2597.93258-	S37	:	:	P	75S	Z	37L	3		2A	1	21	.22
13	13	13	55.5002208+	17	5	2597.93258-	S14	:	:	P	52S	Z	15L	1	19	2A	1	26	.43
14	14	14	55.5486741+	16		2597.72378-	S15	:	:	P	53S	Z	16L	2		2A	1	26	.19
15	15	15	61.5227589+	16	6	2579.21765-	S1	:	:	P	39S	P	1L	1	11	3A	2	31	.46
16	16	16	61.5227589+	16	3	2579.21765-	S20	:	:	P	58S	Z	21L	1	37	4A		34	.50
17	17	17	61.5227589+	16	2	2579.21765-	S27	:	:	P	65S	Z	28L	1	37	5A		36	.48
18	18	18	61.5474367+	15		2578.02148-	S28	:	:	P	66S	Z	29L	2		5A		36	.17
19	19	19	62.1726274+	14	1	2569.39966-	S29	:	:	P	67S	Z	27L	1	37	6A		37	.30
20	20	20	62.6401077+	13	2	2564.16321-	S26	:	:	P	64S	Z	30L	1	37	7A		39	.44
21	21	21	63.1310124+	12	3	2525.36102-	S16	:	:	P	54S	Z	17L	1	74	9B		43	.81
22	22	22	66.8958490+	11		2505.26748-	S21	:	:	P	59S	Z	19L	2		9B		43	.16
23	23	22	70.7546061+	11		2455.59396-	S30	:	:	P	68S	P	39S	3		9B		43	.16
14	DINV	INVERT									DOINV		DEMAND 36527					42198	12
15	CURNT	CURRENT																42202	13
45		PRIMAL																42202	13

Tinker AFB Iterations, N=37--Suboptimal Solution

B711T 01 04/29/80 GENERATOR FUEL ALLOCATION PLAN VERB= OUTPUT PAGE 19

PRNAM=GFP : : FUNCT= 70.7566061+ OBJ=TIME : : RHS=RHSV : :

ROWS

SLACK VALUES

ROW KJ	TYPE	ROW NAME	LOGICAL INDIC.		L-VALUE	PI	RHS
1.	PLUS	FUEL			. +	.04319622+	23436.00000000+
2	ZERO	TC1			. +	.35253991+	131.39700126-
3	ZERO	TC2			. +	.85743821-	65.47599083+
4	ZERO	TC3	*BASIS	(	19.57000031+)	1.00000000-	85.49099922+
5	ZERO	TC4			. +	.87039837-	73.15800094-
6	ZERO	TC5	*BASIS	(	42.71399961+)	1.00000000-	115.87199974+
7	ZERO	TC6			. +	.39947509-	157.61600113-
8	ZERO	TC7			. +	.61975159-	2.89619997+
9	ZERO	TC8	*BASIS	(	10.22720020+)	1.00000000-	164.94699859+
10	ZERO	TC9	*BASIS	(	520.05299377+)	1.00000000-	520.05299377+
11	ZERO	TC10	*BASIS	(	624.99980552-)	1.00000000+	673.97000500-
12	ZERO	TC11			. +	.61988544+	40.92019987+
13	ZERO	TC12	*BASIS	(	26.42619919-)	1.00000000+	40.89230013-
14	ZERO	TC13			. +	.41785590+	. +
15	ZERO	TC14			. +	.16580983-	. +
16	ZERO	TC15			. +	.74803476-	.10440000+
17	ZERO	TC16			. +	.89139655-	22.36169902+
18	ZERO	TC17	*BASIS	(	106.99899864+)	1.00000000-	106.99899864+
19	ZERO	TC18			. +	.87755969+	150.56700134-
20	ZERO	TC19			. +	.65720321+	147.00000000+
21	ZERO	TC20			. +	.58382026+	. +
22	ZERO	TC21			. +	.51035731+	105.00000011-
23	ZERO	TC22	*BASIS	(	85.58300007+)	1.00000000-	203.02999878+
24	ZERO	TC23			. +	.85743821-	299.39400100-
25	ZERO	TC24	*BASIS	(	303.02960191+)	1.00000000-	602.42359924+
26	ZERO	TC25	*BASIS	(	561.02609102-)	1.00000000+	592.90200042-
27	ZERO	TC26			. +	.17924722+	5.26030004-
28	ZERO	TC27			. +	.20006734-	. +
29	ZERO	TC28			. +	.58098191-	.63169999+
30	ZERO	TC29			. +	.00120007-	7.67459999+
31	ZERO	TC30			. +	.85743821-	8.12370002-
32	ZERO	TC31	*BASIS	(	74.96609235+)	1.00000000-	111.94969986+
33	ZERO	TC32	*BASIS		. +	. +	. +
34	ZERO	TC33	*BASIS		. +	. +	. +
35	ZERO	TC34	*BASIS		. +	. +	. +
36	ZERO	TC35	*BASIS		. +	. +	. +
37	ZERO	TC36			. +	2.94854736+	120.00000000-
38	FREE	TIME	*BASIS		70.75660610+	. +	. +

Tinker AFB Slack Values

R711T 01 04/29/80 GENERATOR FUEL ALLOCATION PLAN VERB= OUTPUT PAGE 20

PPNAM=GFP : : FUNCT= 70.7566061+ OBJ=TIME : : RHS=RHSV : :

COLUMNS

Generator #

FUEL ALLOCATIONS

COL	KJ	TYPE	COLUMN NAME	STRUCT. INDIC.	X-VALUE	DJ	COST*SCALE
	39	PLUS	S1		. .	.04582616+	.00207000-
	40	PLUS	S2	*BASIS	3600.58823397+	. .	.00097000-
	41	PLUS	S3	*BASIS	217.56105295+	. -	.00019000-
	42	PLUS	S4		. .	.11942790+	.01590000-
	43	PLUS	S5	*BASIS	219.49595117+	. -	.00900000-
	44	PLUS	S6		. .	.50511990+	.02079000-
	45	PLUS	S7	*BASIS	803.75319171+	. -	.00530000-
	46	PLUS	S8	*BASIS	1361.97005057+	. .	.00307000-
	47	PLUS	S9		. .	.04319622+	.01590000-
	48	PLUS	S10		. .	.15679622+	.00154000-
	49	PLUS	S11	*BASIS	430.40398640+	. -	.00307000-
	50	PLUS	S12		. .	.00639243+	.00307000-
	51	PLUS	S13	*BASIS	303.10624431+	. -	.00200000-
	52	PLUS	S14	*BASIS	303.10624050+	. -	.00200000-
	53	PLUS	S15	*BASIS	303.10623669+	. -	.00200000-
	54	PLUS	S16	*BASIS	73.00098965+	. .	.00019000-
	55	PLUS	S17		. .	.02109900+	.00530000-
	56	PLUS	S18		. .	.00393926+	.00059000-
	57	PLUS	S19	*BASIS	800.60275934+	. .	.00530000-
	58	PLUS	S20	*BASIS	19.67176819+	. -	.01590000-
	59	PLUS	S21	*BASIS	19.67176794+	. -	.00077000-
	60	PLUS	S22	*BASIS	4186.53843840+	. .	.00019000-
	61	PLUS	S23		. .	.00639244+	.00019000-
	62	PLUS	S24	*BASIS	908.09900311+	. -	.00087000-
	63	PLUS	S25		. .	.10379622+	.00142000-
	64	PLUS	S26	*BASIS	605.66044532+	. -	.00307000-
	65	PLUS	S27	*BASIS	326.70810312+	. -	.00307000-
	66	PLUS	S28	*BASIS	326.70810044+	. -	.00530000-
	67	PLUS	S29	*BASIS	106.17150328+	. .	.02079000-
	68	PLUS	S30	*BASIS	37.54530228+	. -	.00019000-
	69	PLUS	S31	*BASIS	122.12411745+	. -	.00112600-
	70	PLUS	S32		. .	.00489622+	.00330000-
	71	PLUS	S33		. .	.04319622+	.00034000-
	72	PLUS	S34		. .	.04319622+	.00034000-
	73	PLUS	S35		. .	.04319622+	.00034000-
	74	PLUS	S36		. .	.11690990+	.00060000-
	75	PLUS	S37	*BASIS	8191.17626507+	. .	.00040000-
	76	RHS	RHSV		. .	2455.59390262-	. .

Tinker AFB Fuel Allocations, N=37

APPENDIX L

TINKER AFB OPTIMAL OUTPUT

F031T 01 04/25/80 GENERATOR FUEL ALLOCATION PLAN VERB= PRIMAL PAGE 17

PRNAM=OFP I : FUNCT= 1.32158583+ OBJ=TIME I : RHS=RHSV I :

ITER	ETA	NUB	FUNCTIONAL	NINFS	NDJS	VALUE2	INCOMING	VECTOR NAME	IN	KJ	OUT	KJ	CCT	VPC	ACT	NCT	FCT	A.TIM
1	1	1	1.32158583+	17	5	398.971397-	S11	I	I	P	29S	Z	7L	1	8	.1A	1	6	.101
2	2	2	3.18862568+	16		333.495399-	S2	I	I	P	24S	Z	2L	2		1A	1	6	. 20
3	3	3	3.76988126+	15		321.162399-	S3	I	I	P	25S	Z	3L	3		1A	1	6	. 15
4	4	4	3.84735694+	14		315.369999-	S7	I	I	P	27S	Z	5L	4		1A	1	6	. 14
5	5	5	3.84735694+	14		315.369999-	S13	I	I	P	31S	Z	9L	5		1A	1	6	. 12
6	6	6	3.87312495+	13	5	296.324797-	S24	I	I	P	38S	Z	16L	1	10	1A	1	11	. 31
7	7	7	4.09238231+	12	5	288.296497-	S37	I	I	P	45S	Z	22L	1	21	2A	1	16	. 39
8	8	8	4.34437883+	11	5	288.177798-	S31	I	I	P	44S	Z	21L	1	15	3A	1	21	. 47
9	9	9	4.34437883+	11	5	288.177798-	S14	I	I	P	32S	Z	10L	1	22	4A	1	26	. 40
10	10	10	4.35283231+	10		279.964888-	S15	I	I	P	33S	Z	11L	2		4A	1	26	. 16
11	11	11	6.76792639+	9	4	235.240598-	S16	I	I	P	34S	Z	12L	1	22	5A		30	. 30
12	12	12	10.3362133+	8	4	182.388282-	S17	I	I	P	35S	Z	8L	1	22	6A		34	. 39
13	13	13	10.3362134+	7		182.388282-	S12	I	I	P	30S	Z	6L	2		6A		34	. 15
14	14	14	10.8230446+	6	3	178.374598-	S8	I	I	P	28S	Z	13L	1	22	7A		37	. 36
15	15	15	20.7762444+	5	3	104.692606-	S19	I	I	P	36S	Z	4L	1	22	8A		40	. 30
16	16	16	22.2989566+	4	3	100.358600-	S5	I	I	P	26S	Z	14L	1	22	9A		43	. 37
17	17	17	22.2989566+	4	2	100.358600-	S27	I	I	P	40S	Z	18L	1	22	10A		45	. 32
18	18	18	22.3454838+	3		99.8952885-	S28	I	I	P	41S	Z	19L	2		10A		45	. 12
19	19	19	23.1771588+	2	1	89.8380083-	S29	I	I	P	42S	Z	17L	1	22	11A		46	. 20
20	20	20	23.8983555+	1	1	83.8459997-	S26	I	I	P	39S	Z	20L	1	22	12A		47	. 29
21	21	21	47.5753894+		1	.769208842-	S30	I	I	P	43S	Z	15L	1	22	13A		48	. 43
22	22	22	58.9535384+		1	.026314615-	S22	I	I	P	37S	P	1L	1	22	14A		49	. 36
14	RINV	INVERT										RGINV		DEMAND	36527			46110	11
15	CURNT	CURRENT																46113	12
45		PRIMAL																46113	12

OPTIMAL SOLUTION

Tinker AFB Iterations, N=22

FOSLT 01 04/29/80 GENERATOR FUEL ALLOCATION PLAN VERB= OUTPUT PAGE 19

PRNAM=GFP : : FUNCT= 58.9535384+ OBJ=TIME : : RHS=RHSV : :

SLACK VALUES

ROWS

ROW KJ	TYPE	ROW NAME	LOGICAL INDIC.	L-VALUE	PI	RHS
1	PLUS	FUEL		. +	.00337495+	23436.00000000+
2	ZERO	TC2		. +	.06736557-	65.47599983+
3	ZERO	TC3		. +	.05147431-	12.33299994+
4	ZERO	TC5		. +	.03459740-	41.74400043-
5	ZERO	TC7		. +	.02478001-	2.09619997+
6	ZERO	TC8		. +	.02746523-	40.97020035-
7	ZERO	TC11		. +	.03014072-	40.92019987+
8	ZERO	TC12		. +	.03283220-	40.09230013-
9	ZERO	TC13		. +	.05130754-	. +
10	ZERO	TC14		. +	.06994288-	. +
11	ZERO	TC15		. +	.08849822-	.10440000+
12	ZERO	TC16		. +	.07260697-	22.36169982+
13	ZERO	TC17		. +	.06279030-	28.43199992+
14	ZERO	TC19		. +	.05297363-	41.17599964+
15	ZERO	TC22		. +	.11530473+	96.36360073-
16	ZERO	TC24		. +	.10695255+	9.52159989+
17	ZERO	TC26		. +	.10115032+	5.26030004-
18	ZERO	TC27		. +	.09847484+	. +
19	ZERO	TC28		. -	.11541473+	.63169999+
20	ZERO	TC29		. +	.20423077+	7.62459999+
21	ZERO	TC30		. +	.21049059+	8.12370002-
22	ZERO	TC31		. +	.20306031+	8.03030002-
23	FREE	TIME	*BASIS	58.95353888+	1.00000000+	. +

Tinker AFB Slack Values, N=22

FASIT 01 04/25/80 GENERATOR FUEL ALLOCATION PLAN VERB= OUTPUT PAGE 20

PRNAM=GFP : : FUNCT= 50.9535384+ OBJ=TINF : : RHS=RHSV : :

COLUMNS

Generator #

FUEL ALLOCATIONS

COL	KJ	TYPE	COLUMN NAME	STRUCT. INDIC.	X-VALUE	DJ		COST*SCALE
	24	PLUS	S2	*BASIS	2647.37023021+	.	-	.00097000-
	25	PLUS	S3	*BASIS	95.81957690+	.	+	.00819000-
	26	PLUS	S5	*BASIS	50.10600570+	.	-	.00900000-
	27	PLUS	S7	*BASIS	290.03330932+	.	+	.00530000-
	28	PLUS	S8	*BASIS	400.90002779+	.	+	.00307000-
	29	PLUS	S11	*BASIS	919.29189816+	.	-	.00307000-
	30	PLUS	S12	*BASIS	400.80790768+	.	-	.00307000-
	31	PLUS	S13	*BASIS	1409.45240654+	.	-	.00200000-
	32	PLUS	S14	*BASIS	1409.45246882+	.	-	.00200000-
	33	PLUS	S15	*BASIS	1409.45245111+	.	-	.00200000-
	34	PLUS	S16	*BASIS	344.34331799+	.	+	.00819000-
	35	PLUS	S17	*BASIS	418.02307596+	.	+	.00530000-
	36	PLUS	S19	*BASIS	273.03587120+	.	-	.00530000-
	37	PLUS	S22	*BASIS	432.30896620+	.	+	.00819000-
	38	PLUS	S24	*BASIS	358.84463361+	.	-	.00082000-
	39	PLUS	S26	*BASIS	1085.01469390+	.	+	.00307000-
	40	PLUS	S27	*BASIS	919.29446437+	.	-	.00307000-
	41	PLUS	S28	*BASIS	919.29445603+	.	+	.00530000-
	42	PLUS	S29	*BASIS	529.56405936+	.	+	.02079000-
	43	PLUS	S30	*BASIS	125.08101894+	.	-	.00819000-
	44	PLUS	S31	*BASIS	344.34329495+	.	+	.00112600-
	45	PLUS	S37	*BASIS	7670.05583442+	.	+	.00040000-
	46	RHS	RHSV		. +	50.95353888+		. +

Tinker AFB Fuel Allocations, N=22

APPENDIX M

KELLY AFB INPUT PROGRAMS

Kelly AFB Original Input Program

```
10##S,R(J) :,8,16;;,16
15$:IDENT:WP1186, MOTT/NELSON THESIS
20$:USERID:80A053$KR79
25$:PROGRAM:RLHS
30$:LIMITS:10,39K,,5K
35$:PRMFL:H*,R,R,AF.LIB/LP.FAC
40$:REMOTE:SO,SL
45$:DISC:AA,A1,10R
50$:DISC:AB,A2,10R
55$:DISC:AC,A3,10R
60$:DISC:AD,A4,10R
65$:DISC:AE,A5,10R
70$:DATA:IN
75FILE:ELEC
80**** KELLY AFB FUEL PLAN ****
85****                      ****
90**** CONSTRAINT MATRIX ****
95****                   ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S1(P)=1
110:,S2(P)=1
115:,S3(P)=1
120:,S4(P)=1
125:,S5(P)=1
130:,S6(P)=1
135:,S7(P)=1
140:,S8(P)=1
145:,S9(P)=1
150:,S10(P)=1
155:,S11(P)=1
160:,S12(P)=1
165:,S13(P)=1
170:,S14(P)=1
175:,S15(P)=1
180:,S16(P)=1
185:,S17(P)=1
190:,S18(P)=1
195:,S19(P)=1
200:,S20(P)=1
205:,S21(P)=1
210:,S22(P)=1
215:,S23(P)=1
220:,S24(P)=1
225:,S25(P)=1
230:,S26(P)=1
235:,S27(P)=1
240:,S28(P)=1
245:,S29(P)=1
250:,S30(P)=1
255:,S31(P)=1
260:,S32(P)=1
```

```
265:,S33(P)=1
270:,S34(P)=1
275:,S35(P)=1
280:,S36(P)=1
285:,S37(P)=1
290:,S38(P)=1
295****   TIME EQUALITY CONSTRAINTS   ****
300MATRIX:TC1(Z),S1=.1961
305:,S2=-.1136
310A:TC2(Z),S2=.1136
315:,S3=-.2500
320A:TC3(Z),S3=.2500
325:,S4=-.1136
330A:TC4(Z),S4=.1136
335:,S5=-.1538
340A:TC5(Z),S5=.1538
345:,S6=-.1538
350A:TC6(Z),S6=.1538
355:,S7=-.1136
360A:TC7(Z),S7=.1136
365:,S8=-.3030
370A:TC8(Z),S8=.3030
375:,S9=-.1136
380A:TC9(Z),S9=.1136
385:,S10=-.1961
390A:TC10(Z),S10=.1961
395:,S11=-.5882
400A:TC11(Z),S11=.5882
405:,S12=-.0625
410A:TC12(Z),S12=.0625
415:,S13=-.1961
420A:TC13(Z),S13=.1961
425:,S14=-.7692
430A:TC14(Z),S14=.7692
435:,S15=-.4
440A:TC15(Z),S15=.4000
445:,S16=-.3030
450A:TC16(Z),S16=.3030
455:,S17=-.3030
460A:TC17(Z),S17=.3030
465:,S18=-.3030
470A:TC18(Z),S18=.3030
475:,S19=-.1961
480A:TC19(Z),S19=.1961
485:,S20=-.5882
490A:TC20(Z),S20=.5882
495:,S21=-.1136
500A:TC21(Z),S21=.1136
505:,S22=-.1136
510A:TC22(Z),S22=.1136
515:,S23=-.3030
```

```
520A:TC23(Z),S23=.3030
525:,S24=-.0741
530A:TC24(Z),S24=.0741
535:,S25=-.5
540A:TC25(Z),S25=.5
545:,S26=-.5
550A:TC26(Z),S26=.5
555:,S27=-.125
560A:TC27(Z),S27=.125
565:,S28=-.0625
570A:TC28(Z),S28=.0625
575:,S29=-.25
580A:TC29(Z),S29=.25
585:,S30=-.25
590A:TC30(Z),S30=.25
595:,S31=-.25
600A:TC31(Z),S31=.25
605:,S32=-.25
610A:TC32(Z),S32=.25
615:,S33=-.25
620A:TC33(Z),S33=.25
625:,S34=-.0625
630A:TC34(Z),S34=.0625
635:,S35=-.0625
640A:TC35(Z),S35=.0625
645:,S36=-.125
650A:TC36(Z),S36=.125
655:,S37=-.25
660A:TC37(Z),S37=.25
665:,S38=-.0816
670****                                    ****
675****  OBJECTIVE FUNCTION                ****
680****                                    ****
685MATRIX:TIME(FREE),S1=-.00516
690:,S2=-.00299
695:,S3=-.00658
700:,S4=-.00299
705:,S5=-.00405
710:,S6=-.00405
715:,S7=-.00299
720:,S8=-.00797
725:,S9=-.00299
730:,S10=-.00516
735:,S11=-.01548
740:,S12=-.001645
745:,S13=-.00516
750:,S14=-.02024
755:,S15=-.01053
760:,S16=-.00797
765:,S17=-.00797
770:,S18=-.00797
```

```
775:,S19=-.00516
780:,S20=-.01548
785:,S21=-.00299
790:,S22=-.00299
795:,S23=-.00797
800:,S24=-.00195
805:,S25=-.01316
810:,S26=-.01316
815:,S27=-.003289
820:,S28=-.001645
825:,S29=-.00658
830:,S30=-.00658
835:,S31=-.00658
840:,S32=-.00658
845:,S33=-.00658
850:,S34=-.001645
855:,S35=-.001645
860:,S36=-.00329
865:,S37=-.00658
870:,S38=-.00215
875****                        ****
880****  RIGHT HAND SIDE VALUES  ****
885****                          ****
890****   FUEL QUANTITY CONSTRAINT  ****
895RHS:FUEL,RHSV=10290
900****   TIME EQUALITY CONSTRAINTS   ****
905:TC1=-194.81
910:TC2=-19.19
915:TC3=2.15
920:TC4=2.36
925:TC5=0.0
930:TC6=139.64
935:TC7=-79.5
940:TC8=-79.54
945:TC9=228.89
950:TC10=-204.958
955:TC11=-4.042
960:TC12=64.85
965:TC13=96.2
970:TC14=-92.3
975:TC15=-24.25
980:TC16=75.75
985:TC17=-75.75
990:TC18=164.5
995:TC19=-93.2
1000:TC20=614.07
1005:TC21=-736.128
1010:TC22=126.508
1015:TC23=-143.7222
1020:TC24=112.2222
1025:TC25=0
```

```
1030:TC26=0
1035:TC27=0
1040:TC28=0
1045:TC29=0
1050:TC30=0
1055:TC31=0
1060:TC32=0
1065:TC33=0
1070:TC34=0
1075:TC35=0
1080:TC36=0
1085:TC37=-120
1090END***
1095$:DATA:I*
1100:PREPRO
1105:TITLE:GENERATOR FUEL ALLOCATION PLAN
1110:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
1115:SETUP:SOURCE=GFP
1120:SET:OBJ=TIME,RHS=RHSV
1125:PICTURE
1130:PRIMAL
1135:OUTPUT
1140:ENDLP
1145$:ENDJOB
1150***EOF
```

Kelly AFB Adjusted Input Program

```
10##S,R(SL) :,8,16;;,16
15$:IDENT:WP1186, MOTT/NELSON THESIS
20$:USERID:80A053$KR79
25$:PROGRAM:RLHS
30$:LIMITS:10,39K,,5K
35$:PRMFL:H*,R,R,AF.LIB/LP.PAC
40$:REMOTE:SO,SL
45$:DISC:AA,A1,10R
50$:DISC:AB,A2,10R
55$:DISC:AC,A3,10R
60$:DISC:AD,A4,10R
65$:DISC:AE,A5,10R
70$:DATA:IN
75FILE:ELEC
80**** KELLY AFB FUEL PLAN ****
85****                      ****
90**** CONSTRAINT MATRIX ****
95****                 ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S2(P)=1
110:,S3(P)=1
115:,S4(P)=1
120:,S5(P)=1
125:,S6(P)=1
130:,S8(P)=1
135:,S9(P)=1
140:,S11(P)=1
145:,S12(P)=1
150:,S13(P)=1
155:,S15(P)=1
160:,S16(P)=1
165:,S18(P)=1
170:,S22(P)=1
175:,S24(P)=1
180:,S38(P)=1
185****   TIME EQUALITY CONSTRAINTS    ****
190MATRIX:TC2(Z),S2=.1136
195:,S3=-.2500
200A:TC3(Z),S3=.2500
205:,S4=-.1136
210A:TC4(Z),S4=.1136
215:,S5=-.1538
220A:TC5(Z),S5=.1538
225:,S6=-.1538
230A:TC6(Z),S6=.1538
235:,S8=-.3030
240A:TC8(Z),S8=.3030
245:,S9=-.1136
250A:TC9(Z),S9=.1136
255:,S11=-.5882
```

```
260A:TC11(Z),S11=.5882
265:,S12=-.0625
270A:TC12(Z),S12=.0625
275:,S13=-.1961
280A:TC13(Z),S13=.1961
285:,S15=-.4
290A:TC15(Z),S15=.4000
295:,S16=-.3030
300A:TC16(Z),S16=.3030
305:,S18=-.3030
310A:TC18(Z),S18=.3030
315:,S22=-.1136
320A:TC22(Z),S22=.1136
325:,S24=-.0741
330A:TC24(Z),S24=.0741
335:,S38=-.0816
340****                                ****
345****  OBJECTIVE FUNCTION           ****
350****                               ****
355MATRIX:TIME(FREE),S2=.00299
360:,S3=-.00658
365:,S4=-.00299
370:,S5=-.00405
375:,S6=-.00405
380:,S8=-.00797
385:,S9=-.00299
390:,S11=-.01548
395:,S12=-.001645
400:,S13=-.00516
405:,S15=-.01053
410:,S16=-.00797
415:,S18=-.00797
420:,S22=-.00299
425:,S24=-.00195
430:,S38=-.00215
435****                         ****
440****  RIGHT HAND SIDE VALUES  ****
445****                           ****
450****   FUEL QUANTITY CONSTRAINT  ****
455RHS:FUEL,RHSV=10290
460****   TIME EQUALITY CONSTRAINTS   ****
465:TC2=-19.19
470:TC3=2.15
475:TC4=2.36
480:TC5=0.0
485:TC6=60.14
490:TC8=-79.54
495:TC9=23.932
500:TC11=-4.042
505:TC12=64.85
510:TC13=3.9
```

```
515:TC15=-24.25
520:TC16=0
525:TC18=-50.758
530:TC22=-17.2142
535:TC24=-7.7778
540END***
545$:DATA:I*
550:PREPRO
555:TITLE:GENERATOR FUEL ALLOCATION PLAN
560:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
565:SETUP:SOURCE=GFP
570:SET:OBJ=TIME,RHS=RHSV
575:PICTURE
580:PRIMAL
585:OUTPUT
590:ENDLP
595$:ENDJOB
600***EOF
```

APPENDIX N

KELLY AFB SUBOPTIMAL OUTPUT

C210T 01 04/14/80 GENERATOR FUEL ALLOCATION PLAN VERB= PRIMAL PAGE 17

PRNAM=GFP : : FUNCT= 2.09352642+ OBJ=TIME : : RHS=RHSV : :

ITER	ETA	NUD	FUNCTIONAL	NINFS	NDJS	VALUE2	INCOMING	VECTOR	NAME	IN	KJ	OUT	KJ	CCT	VPC	ACT	NCT	FCT	A.TIM
1	1	1	2.09352642+	23	5	3335.45838-	S9	:	:	P	48S	Z	9L	1	12	1A	1	6	.125
2	2	2	6.27713953+	22		3176.45838-	S8	:	:	P	47S	Z	8L	2		1A	1	6	.22
3	3	3	6.38352188+	21		3168.36639-	S12	:	:	P	51S	Z	12L	3		1A	1	6	.18
4	4	4	6.44611199+	20		3164.86640-	S3	:	:	P	42S	Z	4L	4		1A	1	6	.14
5	5	5	6.44811199+	20		3164.86640-	S6	:	:	P	45S	Z	6L	5		1A	1	6	.12
6	6	6	9.76985597+	19	5	2911.05838-	S22	:	:	P	61S	Z	23L	1	12	1A	1	11	.33
7	7	7	12.7230718+	18		2686.60599-	S24	:	:	P	63S	Z	25L	2		1A	1	11	.17
8	8	8	15.1752702+	17		2588.20599-	S28	:	:	P	59S	Z	20L	3		1A	1	11	.16
9	9	9	17.1483788+	16		2349.70599-	S19	:	:	P	57S	Z	18L	4		1A	1	11	.16
10	10	10	17.8862331+	15		2300.20599-	S16	:	:	P	55S	Z	16L	5		1A	1	11	.13
11	11	11	17.8862331+	15	5	2300.20599-	S25	:	:	P	64S	Z	26L	1	5	1A	1	16	.40
12	12	12	21.8670190+	14	16	2178.58999-	S11	:	:	P	50S	Z	13L	1	43	2A	4	26	.71
13	13	13	24.1687836+	13		2058.58999-	S38	:	:	P	77S	Z	38L	2		2A	4	26	.17
14	14	14	26.8791582+	12		1955.58999-	S15	:	:	P	54S	Z	17L	3		2A	4	26	.14
15	15	15	27.8833896+	11		1950.86999-	S4	:	:	P	43S	Z	5L	4		2A	4	26	.14
16	16	16	27.8833896+	11		1950.86999-	S26	:	:	P	65S	Z	27L	5		2A	4	26	.13
17	17	17	34.5984454+	10	6	1758.47888-	S13	:	:	P	52S	Z	14L	1	17	3A	2	31	.39
18	18	18	36.1926649+	10		1729.98152-	S5	:	:	P	44S	P	1L	2		3A	2	31	.18
19	19	18	37.7266664+	10	1	1699.81848-	S17	:	:	P	56S	P	44S	1	76	58		32	.68
14	PINV	INVERT										DOINV		DEMAND	36527			42053	12
15	CURNT	CURRENT																42068	12
45		PRIMAL																42068	12

Kelly AFB Iterations, N=38--Suboptimal Solution

C2107 01 04/14/80   GENERATOR FUEL ALLOCATION PLAN   VEPR= OUTPUT PAGE   19

PPNAM=GFP 1 1   FUNCT= 37.7266664+ OBJ=TIME 1 1   RHS=RHSV 1 1

ROWS

SLACK VALUES

ROW KJ	TYPE	ROW NAME	LOGICAL INDIC.	L-VALUE	PI	RHS
1	PLUS	FUEL		. +	.16127744+	10290.00000000+
2	ZERO	TC1	•BASIS	(194.81000137-)	1.00000000+	194.81000137-
3	ZERO	TC2	•BASIS	(14.60000007-)	1.00000000+	19.19000005-
4	ZERO	TC3		. +	.35409821+	2.14999907+
5	ZERO	TC4		. +	1.06480568-	2.35999998+
6	ZERO	TC5		. +	.04861790+	. +
7	ZERO	TC6	•BASIS	(139.63999939+)	1.00000000-	139.63999939+
8	ZERO	TC7		. +	.95196461+	79.50000000-
9	ZERO	TC8		. +	.41969582+	79.54000091-
10	ZERO	TC9	•BASIS	(69.85000075+)	1.00000000-	220.08999939+
11	ZERO	TC10	•BASIS	(47.94999810-)	1.00000000+	204.95000018-
12	ZERO	TC11		. +	.72581190+	4.04700005-
13	ZERO	TC12		. +	1.05462723-	64.04999943+
14	ZERO	TC13		. +	2.67705176-	96.19999981+
15	ZERO	TC14	•BASIS	(11.87419919-)	1.00000000+	92.30000019-
16	ZERO	TC15		. +	.59600639+	24.25000000-
17	ZERO	TC16		. +	.06453760+	75.75000008+
18	ZERO	TC17		. +	.46773119-	75.75000000-
19	ZERO	TC18	•BASIS	(59.07420271+)	1.00000000-	164.50000080+
20	ZERO	TC19		. +	.72581100-	93.70000076-
21	ZERO	TC20	•BASIS	(520.87000011+)	1.00000000-	614.06999969+
22	ZERO	TC21	•BASIS	(609.62000552-)	1.00000000+	736.12000598-
23	ZERO	TC22		. +	.41969582-	126.50799942+
24	ZERO	TC23	•BASIS	(31.49999954-)	1.00000000+	143.72220039-
25	ZERO	TC24		. +	1.17640374-	112.22219944+
26	ZERO	TC25		. +	1.49903063-	. +
27	ZERO	TC26		. +	1.02159352-	. +
28	ZERO	TC27	•BASIS	. +	. +	. +
29	ZERO	TC28	•BASIS	. +	. +	. +
30	ZERO	TC29	•BASIS	. +	. +	. +
31	ZERO	TC30	•BASIS	. +	. +	. +
32	ZERO	TC31	•BASIS	. +	. +	. +
33	ZERO	TC32	•BASIS	. +	. +	. +
34	ZERO	TC33	•BASIS	. +	. +	. +
35	ZERO	TC34	•BASIS	. +	. +	. +
36	ZERO	TC35	•BASIS	. +	. +	. +
37	ZERO	TC36	•BASIS	. +	. +	. +
38	ZERO	TC37		. +	1.97643928+	120.00000000-
39	FREE	TIME	•BASIS	37.72666668+	. +	. +

Kelly AFB Slack Values, N=38

C2181 81 04/14/80 GENERATOR FUEL ALLOCATION PLAN VERR= OUTPUT PAGE 20

PRNAM=GFP : : FUNCT= 37.7246664+ OBJ=TIME : : RHS=RHSV : :

COLUMNS

FUEL ALLOCATIONS

Generator #

COL	KJ	TYPE	COLUMN NAME	STRUCT. INDIC.	X-VALUE	DJ	COST*SCALE
	40	PLUS	S1		. +	.35737744+	.00516000-
	41	PLUS	S2		. +	.16127744+	.00299000-
	42	PLUS	S3	*BASIS	18.03999992+	. +	.00658000-
	43	PLUS	S4	*BASIS	28.77464778+	. -	.00299000-
	44	PLUS	S5		. +	.33252199+	.00405000-
	45	PLUS	S6	*BASIS	. +	. +	.00405000-
	46	PLUS	S7		. +	.38302062+	.00299000-
	47	PLUS	S8	*BASIS	262.37623494+	. +	.00797000-
	48	PLUS	S9	*BASIS	1399.99999834+	. +	.00299000-
	49	PLUS	S10		. +	.55347744+	.00516000-
	50	PLUS	S11	*BASIS	266.92961888+	. -	.01548000-
	51	PLUS	S12	*BASIS	2576.88888241+	. -	.00164500-
	52	PLUS	S13	*BASIS	490.56604869+	. -	.00516000-
	53	PLUS	S14		. +	2.90966547+	.02824000-
	54	PLUS	S15	*BASIS	283.06450137+	. -	.01053000-
	55	PLUS	S16	*BASIS	348.18494775+	. -	.00797000-
	56	PLUS	S17	*BASIS	98.10494602+	. +	.00797000-
	57	PLUS	S18	*BASIS	348.18494276+	. -	.00797000-
	58	PLUS	S19		. +	.21504573+	.00516000-
	59	PLUS	S20	*BASIS	150.44950748+	. +	.01548000-
	60	PLUS	S21		. +	.38847744+	.00299000-
	61	PLUS	S22	*BASIS	1113.62675734+	. -	.00299000-
	62	PLUS	S23		. +	.59144528+	.00797000-
	63	PLUS	S24	*BASIS	1514.46963108+	. -	.00195000-
	64	PLUS	S25	*BASIS	. +	. -	.01316000-
	65	PLUS	S26	*BASIS	. +	. -	.01316000-
	66	PLUS	S27		. +	.38897663+	.00328900-
	67	PLUS	S28		. +	.16127744+	.00164500-
	68	PLUS	S29		. +	.16127744+	.00658000-
	69	PLUS	S30		. +	.16127744+	.00658000-
	70	PLUS	S31		. +	.16127744+	.00658000-
	71	PLUS	S32		. +	.16127744+	.00658000-
	72	PLUS	S33		. +	.16127744+	.00658000-
	73	PLUS	S34		. +	.16127744+	.00164500-
	74	PLUS	S35		. +	.16127744+	.00164500-
	75	PLUS	S36		. +	.16127744+	.00329000-
	76	PLUS	S37		. +	.65538726+	.00658000-
	77	PLUS	S38	*BASIS	1470.58823258+	. +	.00215000-
	78	RHS	RHSV		. +	1699.01040677-	. +

Kelly AFB Fuel Allocations, N=38

APPENDIX O

KELLY AFB OPTIMAL OUTPUT

G032T 01 04/17/80 GENERATOR FUEL ALLOCATION PLAN VERB= PRIMAL PAGE 15

PRNAM=GFP : : FUNCT= .629980351+ OBJ=TIME : : RHS=RHSV : :

ITER	ETA	NUB	FUNCTIONAL	NINFS	NOJS	VALUE2	INCOMING	VECTOR	NAME	IN	KJ	OUT	KJ	CCT	VPC	ACT	NCT	FCT	A.TIM
1	1	1	.629980351+	12	5	312.239998-	S9	:	:	P	24S	Z	8L	1	10	1A	1	6	.88
2	2	2	.736285791+	11		384.155998-	S12	:	:	P	26S	Z	9L	2		1A	1	6	.10
3	3	3	.792473792+	10		299.855999-	S3	:	:	P	19S	Z	3L	3		1A	1	6	.22
4	4	4	.792973792+	10		299.855999-	S6	:	:	P	22S	Z	5L	4		1A	1	6	.12
5	5	5	5.14757032+	9	5	189.630999-	S11	:	:	P	25S	Z	7L	1	16	2A	1	11	.34
6	6	6	5.34858009+	8		180.962288-	S38	:	:	P	33S	Z	14L	2		2A	1	11	.14
7	7	7	5.51273149+	7		176.142198-	S4	:	:	P	20S	Z	4L	3		2A	1	11	.14
8	8	8	5.51273149+	7		176.142198-	S16	:	:	P	29S	Z	13L	4		2A	1	11	.12
9	9	9	7.85762689+	6	5	146.782288-	S5	:	:	P	21S	Z	2L	1	16	3A	1	16	.34
10	10	10	7.96519255+	5		129.567999-	S24	:	:	P	32S	Z	15L	2		3A	1	16	.14
11	11	11	11.9742751+	4	5	78.8999994-	S27	:	:	P	31S	Z	14L	1	16	4A	1	21	.35
12	12	12	15.5649696+	3		33.3499994-	S2	:	:	P	18S	Z	6L	2		4A	1	21	.15
13	13	13	18.7568637+	2		9.89999966-	S18	:	:	P	38S	Z	12L	3		4A	1	21	.16
14	14	14	19.7141584+	1		3.89999997-	S8	:	:	P	23S	Z	10L	4		4A	1	21	.14
15	15	15	28.5353365+			.196899998-	S13	:	:	P	27S	Z	11L	5		4A	1	21	.13
16	16	16	29.1751283+		1	.147398824-	S15	:	:	P	28S	P	1L	1	16	5A		22	.34

DOINV DEMAND 36527 48037 10

48843 10

48843 11

14 DINV INVERT

15 CURNT CURRENT

45 PRIMAL

OPTIMAL SOLUTION

Kelly AFB Iterations, N=16

R032T 01 04/17/80   GENERATOR FUEL ALLOCATION PLAN   VERB= OUTPUT PAGE 17

PHNAM=RFP : :   FUNCT= 29.1751283+ OBJ=TIME : :   RHS=RHSV : :

ROWS

SLACK VALUES

RIGHT-HAND SIDE VALUES

ROW NO	TYPE	ROW NAME	LOGICAL INDIC.	L-VALUE	PI	RHS
1	PLUS	FUEL		. +	.00325608+	10290.00000000+
2	ZERO	TC2		. +	.05499389-	19.19000005-
3	ZERO	TC3		. +	.04168740-	2.14999997+
4	ZERO	TC4		. +	.04402965-	2.35999998+
5	ZERO	TC5		. +	.03886762-	. +
6	ZERO	TC6		. +	.03378558-	60.13999986+
7	ZERO	TC8		. +	.01014809-	79.54000091-
8	ZERO	TC9		. +	.02049833-	23.93199992+
9	ZERO	TC11		. +	.00029158+	4.84200005-
10	ZERO	TC12		. +	.02548568-	64.84999943+
11	ZERO	TC13		. +	.01577676-	3.89999997+
12	ZERO	TC15		. +	.00248804+	24.25000000-
13	ZERO	TC16		. +	.01796554+	. +
14	ZERO	TC18		. +	.03352303+	50.75000037-
15	ZERO	TC22		. +	.03118879+	17.21420002-
16	ZERO	TC24		. +	.01355489+	7.77780002-
17	FREE	TIME	*BASIS	29.17512842+	1.00000000+	. +

Kelly AFB Slack Values, N=16

00327 01 04/17/80 GENERATOR FUEL ALLOCATION PLAN VERB= OUTPUT PAGE 18

PNNAN=GFP : : FUNCT= 29.1751283+ OBJ=TIME : : RHS=RHSV : :

COLUMNS

Generator #

FUEL ALLOCATIONS

COL	KJ	TYPE	COLUMN NAME	STRUCT. INDIC.	X-VALUE		DJ		COST•SCALE	
	18	PLUS	S2	•BASIS	686.68381885	+	.	+	.00299000	+
	19	PLUS	S3	•BASIS	388.78912698	+	.	+	.00650000	-
	20	PLUS	S4	•BASIS	836.68381296	+	.	-	.00299000	-
	21	PLUS	S5	•BASIS	682.64811562	+	.	+	.00405000	-
	22	PLUS	S6	•BASIS	682.64810832	+	.	-	.00405000	-
	23	PLUS	S8	•BASIS	187.41676093	+	.	+	.00797000	-
	24	PLUS	S9	•BASIS	986.68379121	+	.	-	.00299000	-
	25	PLUS	S11	•BASIS	149.87296528	+	.	+	.01540000	-
	26	PLUS	S12	•BASIS	1475.15644813	+	.	+	.00164500	-
	27	PLUS	S13	•BASIS	139.45577787	+	.	+	.00516000	-
	28	PLUS	S15	•BASIS	58.61819428	+	.	-	.01053000	-
	29	PLUS	S16	•BASIS	157.41675623	+	.	-	.00797000	-
	30	PLUS	S18	•BASIS	157.41675429	+	.	+	.00797000	-
	31	PLUS	S22	•BASIS	866.68374925	+	.	+	.00299000	-
	32	PLUS	S24	•BASIS	1560.99156297	+	.	+	.00195000	-
	33	PLUS	S38	•BASIS	1512.83424488	+	.	+	.00215000	-
	34	RHS	RHSV		.	+	29.17512842	+	.	+

Kelly AFB Fuel Allocations, N=16

APPENDIX P

EXAMPLE PROBLEM

The following is an example illustrating the validity of the analysis procedure for determining the maximum length of time that a system of generators can operate on a specified quantity of emergency fuel. For simplicity, only two generators are in the system. The example problem is outlined below.

EXAMPLE PROBLEM INFORMATION

Emergency Generators

Generator #	Fuel Consumption (Gal/Hr)	Fuel Tank Capacity (Gal)
1	3.5	1000
2	7.5	1500

Emergency Fuel Stocks: Total = 10000 gallons

The set of 3 linear equations required for this example problem can be solved by a standard analytical technique for solvinq simultaneous linear equations, and also by the LP600 computer program. Consistent results using the two techniques indicate the validity of the procedures used to derive the linear programming objective function and constraint set, and the validity of the procedure used to obtain the maximum length of time the ALCs can operate from the maximized objective function.

The linear equations for the analytical solution procedure are obtained as follows:

The length of time that generator #1 can operate is T_1.

$$T_1 = S_1/R_1 + F_1/R_1$$
$$T_1 = S_1/3.5 + 100/3.5$$
$$= .2857S_1 + 285.714$$

The length of time that generator #2 can operate is T_2.

$$T_2 = S_2/R_2 + F_2/R_2$$
$$= S_2/7.5 + 1500/7.5$$
$$= .1333S_2 + 200$$

Both generators are required to operate the same length of time, T_{max}, so $T_1 = T_2 = T_{max}$. The linear equations for the length of time each generator can operate now become:

$$T_{max} = .2857S_1 + 285.714$$

for generator #1, and

$$T_{max} = .1333S_2 + 200$$

for generator #2.

The supply constraint is:

$$S_1 + S_2 = 10000$$

The three equations can now be rearranged and solved simultaneously.

$$
\begin{aligned}
T_{max} - .2857S_1 \qquad\qquad &= 285.714 \\
T_{max} \qquad\qquad - .1333S_2 &= 200 \\
S_1 \qquad + S_2 &= 10000
\end{aligned}
$$

Multiply row one by -1 and add to row two.

$$
\begin{aligned}
.2857S_1 - .1333S_2 &= -85.714 \\
S_1 \qquad + S_2 &= 10000
\end{aligned}
$$

Multiple row two by .1333 and add to row one.

$$.419S_1 = 1247.286$$

Or: $$S_1 = 2976.816 \text{ Gallons}$$

Now solve for S_2.

$$
\begin{aligned}
S_1 + S_2 &= 10000 \\
2976.816 + S_2 &= 10000 \\
S_2 &= 7023.184 \text{ Gallons}
\end{aligned}
$$

Solve for T_{max}:

$$
\begin{aligned}
T_{max} - .2857S_1 &= 285.714 \\
T_{max} - (.2857)(2975.816) &= 285.714 \\
T_{max} &= 1134.1066 \text{ Hours} \\
T_{max} &= 68046.3936 \text{ Minutes}
\end{aligned}
$$

The information regarding the two generators is now used to develop the objective function and constraint set for the LP600 program. Note that in this example problem the coefficients and constants are based on a consumption rate expressed in gallons per minute. The objective function is obtained as follows:

$$Z = S_1/NR_1 + S_2/NR_2$$

Since N is 2: $Z = 8.57S_1 + 4S_2$

The supply constraint is:

$$S_1 + S_2 \leq 10000$$

The time equality constraint is:

$$S_1/R_1 - S_2/R_2 = F_2/R_2 - F_1/R_1$$

or: $17.14S_1 - 8.00S_2 = -5142.86$

The constant K, expressed in minutes is:

$$K = F_1/R_1N + F_2R_2N$$

$$K = 8571.428 + 6000$$

$$K = 14571.428 \text{ Minutes}$$

The set of equations, then, to be solved using the LP600 program is:

$$Z = 8.57S + 4S_2$$

$$S_1 + S_2 \leq 10000$$

$$17.14S_1 - 8.00S_2 = -5142.86$$

The LP600 program used to solve the problem and selected computer output products are shown on the following four pages. Though the input format for the LP600 program is not entirely obvious, the input program is included for those who may be familiar with this specific linear program package. The relevant items of information from the output of the program are identified on the three output pages. These are the optimal value for the objective function, and the fuel quantities, S_1 and S_2, allocated to the generators.

From the LP600 output:

$$S_1 = 2977.6 \text{ Gallons}$$

$$S_2 = 7022.39 \text{ Gallons}$$

$$Z = 53607.682 \text{ Minutes}$$

The constant K must be added to the optimal value of the objective function to obtain the actual maximum time that the generators can operate.

$$\begin{aligned} T_{max} &= Z + K \\ &= 53{,}607.68 + 14{,}571.43 \\ &= 68{,}179.11 \text{ Minutes} \\ T_{max} &= 1136.32 \text{ Hours} \end{aligned}$$

The slight differences between these results and those obtained from the analytical procedure can be attributed to decimal round-off error. For most practical purposes, the maximum values obtained by the two procedures can be considered identical. Thus the procedures for developing the objective function and constraint set for the LP600 linear program, and the method for obtaining the maximum time from the optimal value for the objective function and the constant K appear to be valid.

Example Problem Input Program

```
10##S,R(J) :,8,16;;,16
20$:IDENT:WP1186, AFIT LSG S.D. NELSON
30$:USERID:80A053$KR79
40$:PROGRAM:RLHS
50$:LIMITS:10,39K,,5K
60$:PRMFL:H*,R,R,AF.LIB/LP.PAC
70$:REMOTE:S0,SL
80$:DISC:AA,A1,10R
90$:DISC:AB,A2,10R
100$:DISC:AC,A3,10R
110$:DISC:AD,A4,10R
120$:DISC:AE,A5,10R
130$:DATA:IN
140FILE:ELEC
150****  MATRIX  ****
160MATRIX:ONE(Z),S1(P)=17.14
170:,S2(P)=-8.00
180MATRIX:TWO(P),S1=1
190:,S2=1
200****  OBJECTIVE FUNCTION  ****
210MATRIX:OBJROW(FREE),S1=-8.57
220:,S2=-4
230****  RHS  ****
240RHS:ONE,RHSONE=-5142.86
250:TWO=10000
260END***
270$:DATA:I*
280:PREPRO
290:TITLE:GENERATORFUELPLAN
300:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
310:SETUP:SOURCE=GFP
320:SET:OBJ=OBJROW,RHS=RHSONE
330:PICTURE
340:PRIMAL
350:OUTPUT
360:ENDLP
370$:ENDJOB
380***EOF
```

```
P1A5T 01  05/02/80            GENERATORFUELPLAN                                                        VERB= PRIMAL  PAGE    15

PRNAM=GFP   1      1         FUNCT= 2571.43002+  OBJ=OBJROW1      1           RHS=RHSONE1      1

  ITER   ETA    NUB  FUNCTIONAL NINFS  NDJS      VALUE2 INCOMING VECTOR NAME  IN    KJ  _OUT   KJ    CCT   VPC   ACT   NCT   FCT A.TIM
    1     1      1 2571.43002+            1 8.00000000- S2      1       1     P     5S Z     1L     1     2    1A           2  . 62
    2     2      2 53697.6821+            1 17.1400001- S1      1       1     P     4S P     2L     1     2    2A           3  . 78
OPTIMAL SOLUTION
    2     2      2 53687.6821+              17.1400001- S1      1       1     P     4S P     2L           6    5C           3  . 47
   46        OUTPUT                                                                                                    38282     9
```

OPTIMAL SOLUTION

Example Problem Iterations, N=2--Optimal Solution

```
01/51 01  05/02/80                GENERATORFUELPLAN                                                    VERB= OUTPUT  PAGE    16

PROGRAM=CEP   1       1           FUNCT= 53607.6821+  OBJ=OBJROW1       1          RHS=RHSONE1        1

   ROWS

                                          LOGICAL
ROW NO  TYPE        *ROW NAME             INDIC.        L-VALUE                PI                 RHS
     1  ZERO    ONE                                          .         .     .18178282+      5142.86004638-
     2  PLUS    TWO                                          .         .     5.45425619+     10000.00000000+
     3  FREE    OBJROW                   *BASIS     53607.68239185+          1.00000000+            .        .
```

SLACK VALUES

ORIGINAL RIGHT-
HAND SIDE
VALUES

Example Problem Slack Values

```
D1ASI 71  05/02/80            GENERATORFUELPLAN                                          VERB= OUTPUT  PAGE    17

PINAME=GEP   :       :        FUNCT= 53687.6821+  OBJ=OBJROW:       :        RHS=RHSONE:       :

COLUMNS
                                  STRUCT.
COL KJ  TYPE       COLUMN NAME      INDIC.         X-VALUE                DJ                   COST*SCALE
     4  PLUS   S1                  *BASIS         2977.61099249+          .          +         8.57000005-
     5  PLUS   S2                  *BASIS         7022.38900751+          .          +         4.00000000-
     6   RHS   RHSONE                                  .          +   53687.68239185+          .         +
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Generator #

FUEL ALLOCATIONS

Example Problem Fuel Allocations

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